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HISTORY

OF THE



PROGRESS

AND

PRESENT STATE

OF

ANIMAL CHEMISTRY.

BY

W. B. JOHNSON, M.B.

IN THREE VOLUMES.

VOL. I.

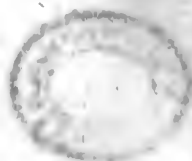
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P R E F A C E.

IT was the precept of an eminent philosopher, that he, who undertakes to extend the limits of a science should previously be made acquainted with the discoveries of his predecessors. To facilitate the application of this precept, first induced the Author to make the following compilation.

That all organized bodies are composed of ultimate or remote parts, will not be denied, but there seems to be a prevalent idea, that it is necessary for these component parts to be in certain proportions or peculiar combinations, in order to establish the equilibrium of health; and that when these are destroyed, disease is the consequence, which cannot be cured until the organic machine receives those parts which are deficient, or gives up those which are in excess, so that the proper proportions be again effected, and the equilibrium of health restored. If such be the case, the conclusion is, that the happiness or misery of individuals depends ultimately on the proportion of the different parts of the substances that compose them.

The human intellect appears to delight in speculation; for the idea has been extended so far as to suppose, that since the mind is only the production of external objects acting on vital organization, conveyed by senses, all of which are composed of ultimate parts; this nobler part of our nature must likewise be within the reach of the powers of the analytical science, and that some distant and future age may be indebted for an explanation not only of the functions of the body, but of the faculties of the mind, to chemical analysis.

At present, there are not a sufficient number of facts to warrant a conclusion, that these speculative opinions can ever be verified, although, from the discoveries chemistry

has already made, and the vast extent of it's capacity for future investigation, it perhaps would not be a just way of reasoning to assert the impossibility : who could have believed, thirty years ago, that either fixed air or water was capable of decomposition, that the diamond was nothing but charcoal, and that flesh might be converted into spermaceti ? Yet this science is only in it's infancy, whilst it's progress is deemed to be eternal.

Every attempt is laudable in the cause of humanity, although it should be fruitless, and the chemical physiologist need not be informed of the great importance it would be to medical science to bring these opinions to the test of experiment, to prove or refute them, and to ascertain whether the deficit and surplus in the proportions of the remote parts of organic bodies are not rather to be numbered amongst the *effects* than the *causes* of diseases.

The physiologist who undertakes such an investigation, need not be discouraged at the quicksands of former times into which so many have fallen ; he will find that the present state of chemistry is different from what it was at that unfortunate period, when the extravagancies it introduced into medicine made the alliance dangerous. Modern chemistry has already thrown great light on several parts of the animal system ; it has within these last few years commenced an investigation of several of the functions of the body, and explained the manner in which they are carried on with some degree of success : the processes of respiration, of perspiration, of digestion, of animalization, and the action of oxygen upon vital organization, no longer remain in that state of total darkness in which they were so lately enveloped, whilst the proficiency already attained in this department of the science, has established the animal analysis upon so firm and broad a basis, as to promise in future the happiest results. Other functions remain to be investigated, such as sanguification, ossification, nutrition, and the secretion of the dif-

ferent fluids; to which may be added the action of those powers that produce diseases, and that of medicines on the animal body; but it is by pursuing the same method of analytical reasoning that their operations are to be explained, and their nature thoroughly understood. Every preparation is already made for this grand work, and there is reason to believe, that the route which has hitherto been explored will conduct the philosopher to a more precise and exact knowledge of the phenomena of the animal economy, and to the formation of a more perfect theory of the laws that govern the vital and mental world.

What has been said of the medical science may be extended to the arts. Several of these, it is well known, are indebted to the animal kingdom for their respective materials; and the enlightened artist need not be informed of the great desideratum of having the nature and properties of the materials he employs thoroughly investigated by chemical analysis; it is, perhaps, the only means by which his art can be reduced to scientific principles; by which his operations can be simplified, his processes accelerated, and his labours shortened. It is to this science that the arts of dyeing, tanning, making of glue, of hats, of cutlery, the operations of cookery, the processes of the dairy, &c., have been brought to their present state of perfection, and it is to the same source they can only look for future improvement.

For such an undertaking, a material advantage, however, seemed to be wanting: a compilation in which the enterprising experimentalist could be made acquainted with the facts and observations of those who had preceded him. It is true, several learned foreign chemists have attempted to supply this deficiency, and Gren, Hildebrandt, Jacquin, and de la Grange, have published compilations on the subject; but their plans appear to have been too limited, and their descriptions too concise; many of the phenomena recorded in the analysis of ani-

mal substances have been excluded, some of the most interesting particulars have been forgotten. In the work now presented to the public, a different plan has been pursued, a more enlarged scale has been attempted, and an endeavour has been made to give the whole a more connected and systematic arrangement. For these purposes, the Author is principally indebted for his information to the *Elementa Physiologiæ* of Haller, the *Encyclopédie Méthodique* of Morveau and Fourcroy, and to Leonhardi's German translation of Macquer's *Chemical Dictionary*, with the excellent additions. At the same time, copious extracts have been occasionally selected from more recent publications, particularly those collections of different learned societies, to whose diligence and industry chemistry presents her choicest store. From the former, the early historical part has been chiefly taken; from the latter, the state of analysis of the present day. With such assistance, it is to be hoped, the deficiencies of former compilers may have been in some measure supplied, and the knowledge they have collected increased, by having had access to a more extensive mass of materials, and to later discoveries.

Derby, Dec. 1st, 1802.

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VOL. I.

ERRATA.

Page 1, line 4 from bot. *for* oviparous *read* viviparous—P. 10, l. 31, *dele* for which *vide* caustics—P. 15, l. 3, *for* becomes horn *r.* loses it's oxygen—P. 25, l. 12, *for* is escaped *r.* has escaped—P. 28, l. 20, *dele* 2d.—P. 29, l. 1, *for* off *r.* from—P. 29, l. 7. *for* the acid of *r.* the aid of—P. 56, l. 15, *for* and carbonic *r.* or carbonic—P. 58, l. 19, *for* three quarters *r.* one third—P. 79, l. 15, *for* excess *r.* access—P. 82, l. 8. from bot. *for* fluid *r.* florid—P. 107, last line, *for* alkali *r.* alkaline—P. 108, l. 16, *for* potrethcr *r.* potfetten—P. 118, l. 3, *for* teeth *r.* cutting teeth—P. 120, l. 32, *for* chefe *r.* cheesc—P. 148, l. 6, *for* he procured *r.* he poured—P. 158, l. 22, *for* soda of potash *r.* foda or potash—P. 159, l. 25, *dele* now—P. 199, l. 5, *for* fluid *r.* florid—P. 208, l. 11, fr. bot. *for* fish *r.* fresh—P. 211, l. 5, place the semicolon after *digested*—P. 220, l. 10, *for* refins; united *r.* refins united—P. 222, l. 29, *for* sooner *r.* later—P. 224, l. 2, *dele* by—P. 255, l. 13, *for* viscus *r.* virus—P. 293, l. 1, *for* white parts *r.* 2. white parts—P. 324, l. 23, *for* residua *r.* residuum—P. 379, l. 3. from bot. *for* A *r.* A.—P. 385, l. 6, *for* crystalline *r.* chrysalide—P. 389, l. 4. *for* it *r.* out—ib. l. 2 from bot. *for* action *r.* no action—P. 399, l. 11, *for* nitrous *r.* nitric—P. 401, l. 5, *for* nitre *r.* nitrat—P. 401, l. 8, *for* octoedrical *r.* octoedral—P. 401, last line, *for* when *r.* dephlogisticated muriatic acid—P. 402, l. 11, *for* coal *r.* wool.

THE
HISTORY
OF
ANIMAL CHEMISTRY.

ANIMAL SUBSTANCES.

MAN in consequence of superiour organization, when Animals. compared with all other vital organized beings, has claimed the distinctive mark of placing himself at the head, and of forming a class peculiar to his own species, and almost all naturalists, since the time of Aristotle, have approved of the decision : the remaining part of the animal creation which so far exceeds him in number, has been divided by Daubenton, the French natural historian, into eight classes, viz. Quadrupeds, Cetacea, Birds, oviparous Quadrupeds, Serpents, Fish, Insects, and Worms. Of these classes, very few have, at present, been submitted to chemical investigation ; it is principally to the human subject, and the oviparous quadruped, that the researches of the analytical science extend, although some slight attention has been paid to the oviparous quadrupeds, insects, and worms.

Consist of
different
parts.

Animals, it is well known, consist of a variety of different parts, such as blood, flesh or muscle, membrane, tendon, ligament, fat, nerve, periosteum, brain, cartilage or gristle, bone, hoof, horn, ivory, shell, hair, and feathers, together with other substances that give rise to their colour, smell, and taste. All these parts, as well as the secretions of different kinds, are formed from the blood by various processes of the organized machine, from the nutriment received into the stomach; and by the same means these parts are constantly supported during the life of the particular animal. Whilst this formation and renewal are going on, other matters are separated, such as urine, sweat, and feces, which are excreted and evacuated from the living machine, in the form of useless excrement.

On taking a general view of all these parts and matters, as far as they have been submitted to any chemical analysis, they may be divided into

Division of
animal sub-
stances.

- | | | |
|--------------------|---------------|----------------------|
| 1. Fluids, | 5. Oils, | 9. Colouring Matter, |
| 2. Solids, | 6. Acids, | 10. Concretions, |
| 3. Hard Parts, | 7. Poisons, | and |
| 4. External Parts, | 8. Aromatics, | 11. Excrements. |

Since the formation of these substances is for the most part derived originally from vegetables, and the manner of their conversion has not yet been ascertained, it is supposed that an exact chemical analysis of these parts, and a comparison of their component principles with those of vegetables, may be a means of casting some light upon the operations and nature of the different functions, and lead to a more exact knowledge of the laws of the animal œconomy.

Imperfect
state of it.

Animal Analysis.—The analysis of animal substances is the most difficult and least advanced of any part of chemistry. This neglect has been attributed to several causes, viz.—To the disagreeable products that arise on

submitting them to experiment, which have been found The causes, sufficient to repress the ardour of inquiry; the great want of proper means and methods to treat them; the impossibility of reproducing these matters, or the total absence of every idea of synthesis; and lastly, the small degree of interest which the chemist who was not a professed physician took in the results of their analysis. Such have been the principal circumstances that have arrested the progress of this part of the science.

It was owing to these causes that the old chemists contented themselves with the mere distillation of animal Antient method of analysis. matters in the open fire; an operation which, it is now well known, entirely changes their nature and composition. It is to this science, therefore, when it put on a more modern and philosophic form, that we are to look back for the first traces of a more judicious method of analyzing these substances; and we are indebted to Margraaf, Rouelle, Proust, Macquer, Scheele, and Bergmann, for offering us a more extensive view, and a deeper insight into the principles that compose them.

The advantages, likewise, which a knowledge of the New method. different gases presented to the chemist, and that flow of light which the new French chemical revolution had expanded over a variety of phenomena hitherto obscurely explained, or totally overwhelmed in darkness, enabled the chemist to pursue a different rout from what had been before attempted; and for the present appearance of animal analysis, although still in a very imperfect state, we must have recourse to the indefatigable industry, and the numerous and well conducted experiments of Fourcroy, Marqueron, Vauquelin, Parmentier, Deyeux, Stipriaan, Berthollet, Pearson, Wollaston, and Haggitt.

Forfaking, or at least not relying upon, the decomposition of animal substances by fire alone, according to

the old method, later chemists have tried the effects which those chemical agents have upon them, which are known by the name of reagents, such as the different acids, alkalis, alcohol, &c. ; and they have been submitted to the same operations as chemistry had made use of in the analysis of other bodies, such as separation by repose, expression, decantation, and filtration, either of those fluids which are found mixed together, or contained in various parts of the more solid and hard animal matter. The action they have on the colouring parts has been likewise observed with great care, the different changes they undergo at different temperatures, the animal fluids have been evaporated, and the different salts they contain have been carefully extracted from them, without undergoing any alteration. By pursuing these methods of analysis, the above chemists have made some very important discoveries in the animal kingdom, the component parts of some of it's matters have been exposed, a difference has been found between animal and vegetable substances, and we are enabled to reduce them to some systematic arrangement.

It is by the new method of analyzing that almost every discovery has been made in animal substances, and to it we must have recourse in the prosecution of further inquiries, in order to acquire a complete knowledge of their properties and composition.

Two kinds
of analysis.

On taking a general view of the action of chemical agents on animal substances, the means by which their analysis and decomposition are affected are either natural or artificial. The first comprehends their analysis by putrefaction; the second, by heat and by chemical reagents. The products which ultimately arise, and the new combinations that take place, are, generally speaking, very similar, and the principal difference between them is

perhaps more to be attributed to their slower or quicker decomposition, than to any intervening new species of matter.

1. By Putrefaction, or their spontaneous decomposition, *Natural*, *vide* Putrefaction.

1. By Heat. The action of heat either accelerates *Artificial* their decomposition alone, or when combined with other powers, giving rise to new combinations. The gentle heat of distillation first sends over an aqueous portion from an animal substance, with it's peculiar aroma. On increasing the heat gradually, an empyreumatic oil arises, at first more or less yellow, at last more or less black, according to the degree of heat; then follows volatile alkali in it's liquid or dry state; and when the heat is red or excessive, the aerial fluids are obtained, such as fixed air, hydrogen gas, and a little pure air. The remaining portion is a black coal of difficult incineration, which on being lixiviated afterward, affords salts, such as the phosphats of lime and soda. During this process, the animal matters undergo a total decomposition, and the greater part of the products appear to be new combinations which did not previously exist in the matters, but are formed by the different unions of their component principles. Of the manner however in which these take place there are several opinions. According to the phlogistic system, the elements of animal substances are for the most part pure air, phlogiston, calcareous earth and water; when therefore a distilling heat is applied, the *air* and *water* yield first to the expansive force of the fire, and consequently the first products are principally composed of those two elements; by a greater degree of fire, the phlogiston is separated from the earthy matters, and with a certain proportion of air, water, and earth, forms *oil*; the *volatile alkali* arises from the composition of another part of the phlogiston, and from as much of it as can be

According
to the old
system.

united with water by means of a little of the earth and air. *The acid liquors* are produced from another portion of the air with the organic elements, whilst the *fixed air* only differs from the latter by it's air being combined with a less proportion of them; in the *inflammable gas* there is less air and more phlogiston, it's being of the heavy kind arises from oily matter being dissolved in it; the remaining charcoal consists of the rest of the phlogiston, united with the greatest part of the earth; and finally, the phosphorus was still to be accounted for, although it was considered as a compound substance.

According
to the new
system.

According to the antiphlogistic doctrine, the origin of these products is explained in a different manner. Lavoisier appears to have entertained two opinions respecting their formation, one of which he afterward abandoned, but as it was only the prelude to a more satisfactory method of explanation, it will be necessary to mention it. Berthollet and Fourcroy, and the other French chemists, were of the same opinion. Animal substances they assert contain neither water, carbonic acid gas, nor empyreumatic oil already formed in their composition, but only their elements; a degree of heat a little above boiling water is sufficient to unite the hydrogen with the oxygen, and form water, and the hydrogen and carbon to form oil, whilst the azot and hydrogen produce the volatile alkali. In these substances, as well as in vegetables, the carbon, Lavoisier asserts, is in excess, which is the principal cause perhaps of their action on water; the carbon in excess attracts the oxygen of the water and forms carbonic acid gas, whilst a portion of the hydrogen becoming free, is disengaged, or combines with the carbon to form oil, or with azot, and forms ammonia.

Afterward Lavoisier formed a new theory. He asserts, that three of the principles, viz. hydrogen and oxygen

and azot, have a great tendency to unite with the matter of heat, and take the form of gas, whilst the carbon is a fixed principle, and has very little affinity with the matter of heat, particularly when united with phosphoric acid. If the temperature to which the substance is exposed in distillation does not much exceed that of boiling water, the hydrogen and oxygen unite to form water, which passes over into the receiver. A portion of the hydrogen and of the carbon also unite and form the empyreumatic oil, which is more or less dark coloured, according to its quantity of carbon, whilst another part of the hydrogen unites with the azot and forms the ammonia.

But if instead of a heat nearly equal to boiling water, a red heat be applied to an animal substance, water is no longer formed, or that water, if generated by the first effect of the heat, is decomposed, the oxygen unites with the carbon to which it has a greater affinity at this degree of heat, and forms carbonic acid gas, and the hydrogen being disengaged either unites with the azot to form ammonia, or part of it uniting with the matter of heat escapes in the form of hydrogen gas. At this degree of heat no oil is formed, or if formed would soon be decomposed. The phosphorus remaining combined with the carbon renders it fixed and difficult of incineration. Such are the general products and explanation of the decomposition of animal substances by heat.

We are however informed of other products having been found during this process of distillation, thus Berthollet found a peculiar acid, viz. the zoonic, and when animal substances have been submitted to a very strong degree of heat, it gives rise to the formation of the prussic acid, and even phosphorus.

2. By reagents.

The blue colours of vegetables are changed to a green by the principal fluids of animals, from their containing

soda. Water by the aid of heat extracts the gelatin and coagulates the albumen of animal matters, whilst the fibrin remains behind. The principle of tan precipitates the gelatin. Acids when diluted coagulate the albuminous part; unite with the soda, with which they form a neutral salt; disengage the lime by decomposing the phosphat of that earth, and form with it an earthy salt according to the nature of the acid employed. They likewise unite with the oily parts. If the *fulphuric* acid be used, the substance becomes blackish; if the nitrous, it takes a yellowish hue; and if the latter acid be assisted by a slight elevation of temperature, it is sufficient even in it's weakest state to disengage the azot in the form of gas. When in their concentrated state the acids decompose animal substances by their corroding or caustic property, and during this action new compounds are formed.

The *fulphuric* acid attracts their aqueous part, or if this be in small quantity, a separation of their principles takes place, the azot unites with a portion of hydrogen, and forming volatile alkali combines with the sulphuric acid, or with a vegetable acid, which according to Vauquelin and Fourcroy is a new production, whilst another part of the hydrogen forms with the oxygen that water which is requisite to saturate the sulphuric acid; at the same time the quantity of carbon, which exceeds that required with the hydrogen and oxygen to compose the new acid, remains in the form of a black coal, or if the substance be in a liquid state, in the form of flocks or black powder. During this process there is no evident escape of any volatile principle.

The action of *nitric acid* on animal substances is first to disengage the azot gas from them, they become yellow, and there arises on their surface a kind of crystallizable, inflammable, and bitter varnish; at the same time there is an adipose substance formed, which swims on the top

when the mixture is become liquid, the carbonic and prussic acids arise in the form of elastic fluids, ammonia is produced which saturates the nitrous acid in part, and the substances thus reduced to a vegetable state are found in the portion which remains fixed and liquified with the nitric acid, converted into oxalic acid, and sometimes into the mucous and acetous acids. Another portion of the animal substance forms water, which is either reduced to a vapour or dilutes the salts and acids. In this account of animal decomposition by the nitric acid, each substance is distinguished and characterized by different results; one affords a great deal of azot gas, little ammonia, and much yellow and fat matter; another gives little fat, and an abundance of vegetable acids; a third a deal of prussic acid; in a fourth the mucous or saccholarctic acid formed is very abundant, whilst others do not even show a single trace of it. Some likewise disengage a great deal of carbonic acid gas, others decompose a great quantity of nitrous acid during their decomposition; whilst others, on the contrary, suffer their bond of composition to be dissolved on the least contact of a small proportion of this acid. It is by these differences that the expert chemist may judge of those which characterize the different animal matters.

The *muriatic acid* when combined with heat and applied to animal substances disengages the azot and hydrogen forming ammonia, which by uniting with the muriatic acid gives muriat of ammonia, and hydrogen gas is likewise extricated towards the end of the process.

Neither the sulphuric nor muriatic acid acts with such energy on animal substances as the nitric acid sufficiently concentrated; and the reason why azot gas is extricated in the latter case, whilst it unites with hydrogen in the form of ammonia in the former two, is conjectured to arise from the necessity of heat, so that the azot is in similar circum-

stances as when the animal substance is distilled, in which it combines with the hydrogen; one part of the hydrogen is obliged to take an elastic state.

It is necessary to observe, that with the sulphuric acid very little carbon remains, but a large quantity of carbonic acid gas is obtained; whilst with the muriatic acid, since there remains a much larger proportion of carbon, it is to be presumed that very little carbonic acid gas is disengaged.

Alkalis, when in their mild state, unite with animal acids, forming with them peculiar neutral salts. When in their caustic state, Berthollet affirms, they dissolve animal substances, by which their causticity is taken away; but according to Fourcroy, the disagreeable putrid odour which Berthollet observed proves that something else takes place besides a simple combination. He therefore concludes, that when animal matters are put into a strong caustic alkaline ley, ammonia and caloric are both disengaged; that in proportion as this ammonia is formed the animal matter losing thereby five times a greater quantity of azot than of hydrogen, contains in union with the alkali much more hydrogen than before, and thus contracting an oily character, its alkaline combination is a real soap. Acids decompose it and separate a concrete brown oil from it, whilst earthy and metallic solutions form earthy and metallic saponaceous precipitations.

Lime, barytes, and strontian earth act in the same way, but with less energy.

The calces of metals and metallic salts are likewise powerful caustics, but their action consists in parting with their oxygen and forming a combustion, for which, vide *Caustics*.

Alcohol precipitates the albumen in the form of a coagulum and extracts their resinous parts. Animal substances, when reduced to such a state as only to have their

saline and earthy parts left, are finally examined like other saline and earthy bodies, which it is perhaps unnecessary to mention in their general analysis.

Encyclopédie Méthodique, article *Analysé*.—Berthollet sur la nature des substances animales, Mém. de l'Acad. royale, an. 1784.—Ker's Dictionary of Chemistry, 1 Part p. 186, 194, 195, Birmingham, 1789.—Lavoisier, Réflexions sur la décomposition de l'eau par les substances végétales et animales, Mém. de l'Acad. p. 540, an. 1786.—Of the spontaneous action of concentrated sulphuric acid on vegetable and animal substances, by Cit. Fourcroy and Vauquelin. Nicholson's journal, No. 9. p. 272. Jan. 1786.—Précis d'observations sur l'analyse animale comparée à l'analyse végétale, par M. Berthollet. Journal des Scavans, T. 28. p. 272. Jan. 1786.

FLUIDS.

IN giving an account of the different parts of the animal body, it might perhaps appear more systematic to describe them according to the priority of their formation; but this can only be done with respect to a few. Thus it may be said, that the fluids are formed before the solids; the solids before the hard parts; and the last before the external parts; but it would be difficult to proceed further without much uncertainty: this rule, however, ought to be observed as nearly as possible. The various useful fluids of the animal body appear to be much less in quantity than the solids; and although Gaubius, as well as Cullen, was of opinion that they are formed from the solids, modern authors have reversed the doctrine, and have defended the old system of Harvey, by asserting, it is from the fluid blood that all the remaining fluids, as well as solids, derive their origin. The useful fluids which have been submitted to chemical analysis,

may be divided into eggs, the blood, and its different secretions.

Eggs. *Eggs.*—It is in the egg that we must look for the commencement of vital organization ; but little is known of its developement, or the progress which the embryo makes as it verges towards perfection. Eggs may be distinguished into two different kinds. 1. Those defended by a hard external covering, called the shell, as the eggs of birds. 2. Those which are only provided with a tough membranous covering, as the eggs of different snakes, and some of the oviparous quadrupeds.

The eggs of birds, which are the only kinds that have undergone any chemical investigation, are composed of four parts, viz. 1. A bony shell. 2. A membranous pellicle. 3. The white ; and 4. the yolk. With respect to the 1. and 2. they will be mentioned amongst the hard and solid parts.

The White. *The white or albuminous part.* This part of the egg is **Neumann.** a thickish, transparent, adhesive, viscid fluid. Neumann ranked it among the gelatinous substances, as possessing their viscid and glutinous quality, but although like the gelatins it is capable of being used as a cement for glass and earthen ware, he thought it differed very materially from the other substances of that kind, at least from those extracted from the solid parts of animals, in being not soluble but hardened in boiling water. This coagulation by heat is since found to be one of the distinguishing characters of the white of the egg, by which it forms with several other animal matters, particularly the serum of the blood, a distinct genus, for which, vide *albumen*.

Properties of the white. The white of the egg changes the syrup of violets green from its disengaged soda. It is soluble in cold water, although it does not easily mix with it, on account of its viscosity ; thus 10 parts of water dissolve exactly one part of white, and acids and alcohol precipitate it again

in the form of coagula, as in milk. With aerated water the solution is imperfect, and the white from being perfectly transparent forms a few white streaks, or becomes turbid, according to the quantity of air contained in the water.

Water when heated coagulates the white, before it comes to the boiling point; according to Fourcroy this takes place at 150° , but according to Leonhardi at 160° of Fahr'. In this state it has lost it's transparency, is of a milk colour, and is now entitled to the name of white of egg with great propriety; it is also found to be more or less hard according to the degree of heat applied; thus it is harder when boiled in salt than in fresh water, and still more so in oils. It has also lost some of its weight, for Hoffmann informs us that a hen's egg of 2 oz. 1 drachm (*i. e.* shell little more than 1 drachm; yolk $\frac{1}{2}$ oz. and white $1\frac{1}{2}$ oz.) on being hard boiled lost $1\frac{1}{2}$ drachm, whilst Neumann found that 6 drachms 25 grains of this coagulated white afforded, on being exsiccated, only 55 grains.

Although pure albumen is not soluble in boiling water, yet according to Fourcroy the proportion of water diminishes the tendency of the white to coagulation or solidity, by preventing the near approach of the particles; thus if it be beaten with about one half it's weight of water and then boiled, a much less hard mass is obtained than if none had been used; and he affirms with Scheele, that if the quantity of water be greater, as for instance, if it be mixed with 10 parts, it is even soluble in boiling water, in which the combination resembles skimmed milk or butter milk, a fluid formed for the most part of water and albumen in a particular state, acids added coagulate it again as in milk. When eggs are fresh laid they are not so easily coagulated as others. White of the egg when left to itself, and exposed to a moist warm air,

very soon becomes thinner and thinner until it is putrid : it then resembles urine in smell.

The white on being exposed, a few days during summer, to the sun, Neumann found was converted into a dry and hard mass resembling in consistence and transparency yellowish gum arabic, and when smeared on a piece of paper or other substance by means of a brush, it gives it a transparent varnish like that gum, when dry: Neumann found that ten drachms of the white was reduced on drying to $2\frac{1}{2}$ drachms; this change and loss of weight is attributed to it's being deprived of it's water, which Cartheuser confirms composes nine parts of it. When dried it is still soluble in cold water, and forms the same viscous fluid as before. By distillation in a water-bath nothing is obtained but its water, and in proportion as it loses this, it becomes harder and of a reddish yellowish colour, and resembles horn. If it has been previously coagulated it recovers it's transparency. Exposed on the open fire in a retort, to a strong heat, there comes over a stinking empyreumatic oil with a great quantity of volatile alkali, and a coal remains as in other animal substances.

By sublimation Deyeux obtained a little sulphur from it. Acids coagulate it. Scheele has, however, observed that very diluted acids dissolve it at the boiling point, and it is again precipitated by them in their concentrated state.

It is dissolved by caustic alkalis and lime water, and precipitated from them again by acids; as this takes place an hepatic smell arises, and the vapours blacken silver and saccharum saturni. Cheese having the same properties, Scheele looked upon this matter to be cheese in it's pure state. With lime it forms a very hard cement.

Metallic oxyds, according to Fourcroy, as those of

mercury (which do not form a very strong union with oxygen) thicken it on being agitated with it, whilst the oxyd becomes horn; in twenty-four hours the white was found solid, and the oxyd almost black.

On digestion with iron it is said to dissolve a small portion of it.

Alcohol coagulates it, but soonest when warm.

With respect to the cause of the coagulation of the white of the egg, there has been several opinions. ^{Cause of coagulation of the white.} Scheele thought it arose from caloric or the matter of heat. Wafferberg that it arose from being deprived of it's water, as is the case when it is heated with alcohol, at the same time he thought a specific astringent power was likewise necessary. Fourcroy is of opinion that it arises from the combination of oxygen which is favoured by the heat produced. He divided the white of an egg into two equal parts, to the one he added a solution of carbonate of potash, to the other caustic potash, and he found that sulphuric acid joined to the first produced no coagulation, but formed a thick coagulum on being added to the other; hence he affirms that the sulphuric acid when mixed with the liquid albumen disengages a great deal of caloric from it, which by favouring the intimate combination of the oxygen, produces the coagulation. This effect is still increased by the caustic potash, which unfolds much more caloric than the white itself does, and besides by absorbing the sulphuric acid and preventing it's union with the albumen, the potash proves that it is the impression only of the caloric that gives rise to the concretion: when, on the contrary, the white is mixed with the carbonate of potash in solution, the sulphuric acid joined in the mixture, attacking the salt, disengages the carbonic acid, which takes away the caloric and is volatilized to the state of gas; the white therefore ought not to undergo any alteration, and in fact it remains

without being coagulated. From these and other facts, as that of it's being coagulated by oxyds, Fourcroy seems to suppose oxygen to be the grand principle of coagulation in the white. Against this chemist, however, Corradori brings other experiments. He covered the white of a very fresh egg with olive oil, and exposed it to a heat of boiling water, and found the coagulation took place as if in the open air, although no air had the least access to it, or any elastic air raised the oil in order to escape, so that no decomposition of the water took place. He is also of opinion, that oxygen gas is not even absorbed by the white. He put some white into a branch of a crooked tube, and plunged them into boiling water. The white soon coagulated; and the water in the open branch being always at the same level, proved there was no condensation of air, and the consolidated white had just the same volume as when in a liquid state. He remarks, that the coagulation always begins in that part which is the most distant from the air, or at the bottom of the vessel. His opinion is, that it arises from a change produced by the solvent power of the caloric, in the disposition of the integrant parts of the white to obey the force of cohesion.

Inspissated
white.

Hatchett has made some experiments on *inspissated albumen*. He informs us, that as the albumen of the blood is mixed with gelatin and fibrin, and as it is with some difficulty that the albumen can be separated exactly from these substances, he preferred that of eggs, as being pure and unmixed, and in order that it might be brought into a state in some measure similar to some substances which he had examined (for which *vide* Bone) he dried it after coagulation, in a vessel which was heated to 212 of Fahrenheit, until it became perfectly hard, brittle, yellow, and semitransparent like horn.

1. After digestion of a few hours, the transparent

horny pieces of albumen were softened, and became white and opaque, exactly like albumen recently coagulated. At the end of eight days, the water exactly resembled that afforded by quill, nail, and tortoise-shell; for tanning principle had no effect, although nitro-muriat of tin produced a faint white cloud. The reverse of this takes place in recent liquid albumen, for if the infusion of oak bark be added to it in that state, it immediately forms a precipitate, and nitro-muriat of tin does not produce any effect till some hours have elapsed.

2. By distillation, the coagulated dry semitransparent albumen afforded similar results to those mentioned (in the art. *bone*) as obtained from tortoise-shell, &c.

3. A spongy coal of difficult incineration remained. That which was soluble in water, and which was by far the most considerable, consisted principally of carbonat, mixed with a small quantity of phosphat of soda, the rest, as far as so small a quantity could be ascertained, proved to be phosphat of lime.

4. When steeped in dilute nitric acid, in about four weeks the acid began to be tinged yellow, which gradually became deeper in three months, however the albumen, although less transparent, was but little diminished. The yellow acid solution, when saturated with ammonia, changed to a deep orange colour, and remained transparent.

5. The albumen, thus steeped, was immediately immersed in ammonia, which changed it to a deep orange, inclining to a blood red, and by degrees entirely dissolved it; the solution was of a deep yellowish brown.

6. If the albumen, instead of being immersed in ammonia, was washed, and then boiled in distilled water, it was dissolved and formed a pale yellow liquor, which by evaporation formed a gelatinous mass; this being dissolved again in boiling water was (like gelatin) pre-

precipitated by the tanning principle, and more slowly by nitro-muriat of tin.

7. By concentrated nitric acid, or by the dilute when heated, albumen was speedily dissolved with much effervescence, and a copious discharge of nitrous gas.

8. This solution was like that of tortoise-shell and the other substances (art. *bone*).

9. When evaporated it afforded similar results.

10. Albumen, like tortoise-shell, quill, and nail, was dissolved by boiling lixivium of caustic potash, and formed animal soap.

11. In like manner also a considerable portion of ammonia was discharged, and if the alkali was in excess, some coal was deposited.

12. The animal soap obtained from albumen, when dissolved in water, yielded a precipitate by the addition of acetic or muriatic acid; and the precipitate was redissolved when the acid was added to excess.

13. This precipitate, when collected on a filter, appeared more saponaceous and less viscid than that obtained from the substances art. *bone*; for this precipitate when obtained from hair, wool, and muscular fibre, appeared in some cases more and in others less viscid, although similar in every other property. When gently heated, some oil flowed from it; after which, a brownish viscid substance remained, similar in its properties to that obtained from the animal soap made by tortoise-shell, &c.

14. He found that inspissated albumen, long boiled with distilled water, was apparently diminished; but the water (like that in which tortoise-shell, quill, or nail has been boiled) had acquired the property of becoming white and turbid, when nitro-muriat of tin was added, although it was not changed by the tanning principle. Likewise the water in which albumen, or

tortoise-shell, or nail, had been boiled, became, in some measure, putrid, in a few days, and emitted an offensive smell. He, however, does not look upon this as a proof that any gelatin had been separated from these bodies by means of boiling water, but rather that inspissated albumen, tortoise-shell, &c. are substances really soluble, although in so slight a degree as to approach insolubility; and that, thus, the prevalent opinion has arisen concerning the insolubility of coagulated albumen in boiling water. It does not putrefy in its inspissated semitransparent state.

Albumen, when merely coagulated, does not easily putrify, for Hatchett kept it, when it was soft, white, and coagulated, in water for a month, without its becoming putrid; but that which has not been coagulated, but diluted with water, soon putrefies.

Berthollet, by means of the nitrous acid, extracted from the white a fat matter, and some saccharine acid.

Yolk.—This is a more or less yellow fluid, which in its *Yolk.* fresh state possesses the central part of the white, and is of a globular form. It consists of two parts, the one is an albuminous matter resembling the white; hence it becomes coagulated and hard by exposure to heat, acids, or alcohol, but less so than the white. The other part is a mild fat oil, which appears to exist in the yolk, in the same state as the oil in the seeds of some plants, and it is this oil that forms a very striking analogy between the eggs of animals and the seeds of vegetables. On this account the yolk is not entirely soluble in water, like the white, but forms with it a milk white fluid, which is called an emulsion, resembling that produced from vegetable seeds, and for the same reason it dissolves oily and resinous bodies, and makes them miscible with water. It

likewise contains a considerable quantity of water, which is separated on distillation.

It's oil.

To obtain this oil, there are two ways : First, by expression. The yolk must first be deprived of it's water, by boiling ; it is then to be put into a proper vessel, upon a moderate fire, and kept stirring until it is observed to become somewhat softer, from the exuding of the oil ; this is then to be pressed out from the yolk, by putting it, in a little linen bag, between two warm plates ; by these means Crantz found that fifty eggs afforded five ounces of oil. Secondly, since the heat necessary for roasting produces a change, and a smell, Chandelier has found out a method of procuring the oil in a more perfect state, and in larger proportion, without the aid of fire. Having well beaten the yolks, he put from two to three drachms of rectified alcohol to each, and diluted the mixture with ten times the quantity of water, in which he sometimes dissolved a very small quantity of alum ; he then let it repose twenty-four hours. By this method, from eight yolks he obtained six drachms of oil of eggs. This oil is of a yellowish colour, of a somewhat thickish viscous consistence, mild and insipid ; when, however, it is procured by means of heat, it's taste and smell are slightly empyreumatic. It soon becomes fixed in the cold, and, according to Hildebrandt, it readily turns rancid. What remains of the yolk is albumen, from which, the last chemist has observed, a little gelatin may be extracted by water. The yolk, when boiled with caustic lixivium of potash, forms, according to Hatchett, a pale olive coloured concrete animal soap, which when dissolved in water, and saturated with muriatic acid, is precipitated in the state of mere fat. By incineration, the yolk affords a small portion of the phosphates of soda and of lime.

The yolk, from it's oily and albuminous nature, is used to unite oils, and oily substances, with aqueous fluids, forming *emulsions*, as they are called in medicine ; which likewise forms a striking analogy between eggs and the seeds of most vegetables.

Eggs are commonly preserved by packing them up ^{Preservation of eggs.} very close in bran, sand, sawdust, and other substances that do not admit the free access of air ; the yolk, however, in these cases, suffers a change, by becoming harder. Neumann kept an egg perfectly sweet from May to November, in salt water ; and Reaumur found, that eggs may be kept perfectly sweet for years, by rubbing them *as soon as laid, with oil*, or other unctuous substances.

Wasserberg, examen chemicum ovi, in the collect. Oper. Med. Fasc. 1. p. 184. Scheele in Crell's neuest. Entd. T. viij. S. 150. Chandelier in Vandermonde's Journal de Médecine, T. 16, No. 5, p. 45. Fourcroy, in the Encyclop. Meth. art. albumen. Expériences et Observ. touchant la Cause de la Coagulation de l'Albumine, per le Doct. Carradori. Anfangsgrunde der Chemie von Hildebrandt, T. 3, 1794. Chemical Experiments on Zoophytes, by C. Hatchett, Esq. F. R. S. Phil. Transf. 1800.

Blood.—Life, it is well known, depends upon a fluid ^{Blood.} which circulates through certain kinds of vessels in all animals, and which the ancients very properly expressed by the name of the vital fluid. This has been, at all times, the subject of investigation ; and although, from the important part it acts in the general economy, by carrying life and heat even to the utmost extremities of the organized machine, there is no fluid which requires to be so thoroughly understood, or demands a more serious inquiry ; the nature of the blood, and the laws that govern it's interior movements, in performing the offices it is designed for, have, at present, been but

faintly developed ; and the influence it has over the animal machine, during the various periods of existence, may be even looked upon as entirely unknown.

Two species. Physiologists, from the difference of colour of the blood in various animals, have distinguished it into two kinds.

1. Red blood, which circulates in the arteries, and veins, and other parts, of the mammalia class, birds, amphibious quadrupeds, reptiles, and fish.

2. White blood, which is found in the greater part of worms and insects, and has not yet been submitted to chemical analysis.

From this difference of colour in the blood, those animals whose vessels contain the red have been denominated sanguineous ; and those containing the white, milky, or colourless fluid, exsanguineous animals.

The name of blood has likewise been used in a still more extensive point of view, and has been bestowed upon that fluid which circulates in the vessels of plants.

First species, or red blood.

The first mentioned species alone has yet been analysed. It is the most important fluid in the body, and as to it's component parts, whatever be the diversity of the animal, whether it be an inhabitant of the earth, or of the water, or of the air, nature seems to have followed the same plan ; it therefore affords no characteristic mark whether it be taken from the human body, a quadruped, a fish, or a bird ; it always contains the same component parts. It is subject, however, to constant variety ; it differs greatly, according to the regions through which it passes ; it is not the same in the arteries and in the veins, in the stomach and in the region of the liver, in the muscles and in the glands. It differs, according to the age, the sex, the temperament, and the state of health and disease. It is this variable state of the blood, changing in the proportions and modifications of it's

constituent parts, every moment, even in the same subject, that is the great obstacle towards arriving at a perfect knowledge of it's nature and effects, and determining, by modern discoveries and chemical analysis, the alterations it undergoes from the action of disease.

Blood, as it flows from the vessels of a healthy animal, appears to be a red-homogenous fluid; but, examined by the microscope, small flat balls are discovered, swimming in a thin, somewhat yellowish, liquid; and this is more particularly to be observed as it circulates in the veins of a living animal. It's properties.

It differs, however, in colour, according to the part from which it comes; thus, in the arteries it inclines to a bright vermilion colour, whilst, in the veins, it is of a deep purple. Even in the extremities of the system, the blood of an artery is red, and that of a vein dark coloured; so that surgeons are able to distinguish arterial from venous hæmorrhages. The blood coughed up from the lungs is florid, whilst that of the womb, of sinuses, of varices, and of all stagnant veins, is black and offensive. The face is livid, in apoplexies, strangulations, drowning, in fits of passion, or coughing, or in any accident that interrupts the circulation through the lungs. The face of a child is completely black during the paroxysm of the whooping cough; tumours are dark coloured, from dilated veins that return their blood too slowly; and the mulberry, and other marks, which are born with us, are, according to Bell, small aneurisms full of ill oxygenated blood. The menstrual blood, that of ecchymosis, of aneurismal sacks, are all black; and the blood of varices is so very dark coloured, as to make the ancients suppose they were filled with *atra bilis*, or black bile. With respect to it's quantity, in the human subject, Planck asserts that an adult contains about

twenty-eight pounds of blood ; four parts of which are allotted to the veins, and the remaining fifth to the arteries.

Blood is not so fluid as water, but has an unctuous or saponaceous feel, a sweetish, saline flavour, and it's aroma is somewhat urinous, fatuous, and peculiarly animal ; which aroma is soluble in air, water, and spirituous liquors.

It's specific gravity is greater than distilled water, being as 1053, or 1126 to 1000.

It's heat is different in the different orders of animals ; human blood, and that of quadrupeds and birds, is about 96 of Fahrenheit, or 32 of Reaumur ; whilst, in oviparous quadrupeds, serpents, and fish, it is at the temperature of the medium they inhabit. The arterial blood is likewise warmer than the venous.

It unites with cold water, but boiling water coagulates it. Acids, when very much diluted, have no effect upon fresh blood, but, when concentrated, both the mineral acids and vinegar coagulate it, and change it's red colour to a dark brown.

According to Weber, the fixed and volatile alkalies change it's colour to a beautiful carmine red, without any coagulation ; they even render it more fluid, particularly the latter. The fixed alkalies, when caustic, dissolve it.

Lime water renders it more fluid, and increases it's colour.

Neutral salts, such as nitre, common salt, &c. make it likewise more fluid, heighten it's colour and retard it's coagulation, whilst alum and sal ammoniac coagulate it.

Vitriols of iron and copper, particularly the latter, and spirit of wine when in a concentrated state, likewise coagulate it.

If blood, recently taken from a vein, and either

purple or black, be exposed to oxygen gas, it changes to a vermilion colour, which however gradually disappears and becomes again purple, and lastly black, and no new impregnation can render it red again. On the contrary, if arterial blood, which is of a bright vermilion, be exposed to air in which there is little or no oxygen, *i. e.* to unrespirable gas, it's colour is gradually changed to a purple. *Vide* Respiration. Vassali of Turin found that blood as it comes from an artery or vein is in a state of positive electricity, whilst excretions, as urine, &c. are in a negative state.

The blood, as soon as it is escaped from the vessels, undergoes certain changes; if in a state of repose, it first coagulates into a red gelatinous mass; but it soon begins to separate into two parts. One of these, which is red and solid, is termed the *coagulum* or *clot*: the other is a yellowish fluid, called *serum* or *lymph*, in which the coagulum swims.

If blood as it comes from the vein be put into a vessel void of air, or filled with an unrespirable gas, it likewise coagulates, but not so speedily, nor to that extent as in atmospheric air, and the colour is rather black than red. On the contrary, if recent blood be put into a vessel containing oxygen gas, the coagulation proceeds rapidly, and the colour is as red or more so than if it had been in atmospheric air. According to Beddoes, the respiring oxygen gas hastens it's coagulation. It likewise coagulates more quickly when allowed to flow slowly from a vein, and in small quantities; and more slowly when extravasated in the cellular membrane, than when exposed; in the last case this conglutination first takes place on the exposed surface, and on the edges of the dish.

During the coagulation of blood, according to Fourcroy, a quantity of caloric is disengaged so as to raise it's temperature 5° ,

The coagulation prevented by agitation.

If blood be strongly agitated by any mechanical means as it is received from the vessels, this spontaneous change is prevented, nor can it be coagulated afterwards, according to Weber, either by acids, or alcohol, whilst the alkalis heighten it's colour; and give it more or less transparency; it even becomes perfectly pellucid and fluid on the addition of the aqueous solution of ammonia, and it's colour is changed to that of the most beautiful cochineal. Agitated blood is likewise less inclined to the putrid fermentation.

It's putrefaction.

Blood readily putrefies, according to Weber, when exposed to a temperature of 50° of Fahrenheit; it begins to have a disagreeable smell on the second day, which increases so rapidly as to be nearly insupportable on the fourth; the coagulum then begins to change the serum to a darkish red colour, and it finally becomes so dissolved as only to leave a few threads and lumps, and in this state it has a strong smell of volatile alkali.

Exposure to heat.

Blood, when exposed to a gentle heat, dries into a black mass, termed the extract of blood. On distillation, it affords an insipid phlegm, which quickly putrefies, an empyreumatic oil, and a neutral ammoniacal salt consisting of an acid, which is most probably the zoonic, supersaturated with ammonia. During this operation, the blood becomes very intumescent, evolves much hydrogen, carbonic acid gas, prussic acid, and by an excessive heat, a thick irritating smoke which is phosphorus in a state of combustion; and there remains a heavy spongy coal of difficult incineration, which when reduced to ashes, affords carbonat and muriat of soda, phosphat of lime, and oxyd. of iron.

1. White serum.

Serum. This is a yellowish transparent liquor of a greenish tinge.

It's properties.

It is of an adhesive consistence, has scarcely any aroma, but is somewhat saline to the taste; according to Plenck,

it forms scarcely half of the blood. On agitation it foams exceedingly.

The specific gravity, according to Jurine, is to water as 28 to 1.

It is soluble in water to 55° of Reaumur, or 160° of Fahrenheit, when it coagulates. This is however prevented by dilution with water. In a coagulated state it is of a white colour, resembling boiled white of egg in odour and consistence, and during it's coagulation a slightly turbid liquor separates, which is *gelatin*.

It is to be separated from it's solution in water by alcohol.

It changes the syrup of violets to a green colour.

Acids coagulate it when sufficiently strong, and the liquor remaining after filtration contains a neutral salt arising from the union of the acid and soda, but in small quantity. It is also coagulated by alcohol.

Alkalis render it more fluid.

Serum does not decompose calcareous or aluminous salts, but it acts with sufficient energy in the decomposition of metallic salts.

It blackens the metallic splendour of silver.

During it's coagulation heat is disengaged, and the cause of it's taking this concrete form is owing, according to Fourcroy, to the absorption of oxygen.

Coagulated serum is insoluble in water.

It is soluble in concentrated mineral acids, which solutions are decomposed by water.

Caustic alkalis likewise dissolve this concrete serum, and the solutions are decomposed by acids.

By a moderate heat it dries into a corneous mass.

Hence it appears, that coagulated serum is very similar to the cheesy part of milk.

If coagulated serum be treated with diluted nitric acid, by the aid of heat, nitrous and azot gases will be obtained, Affords
oxalic and
malic acids,

while the oxalic as well as a small portion of malic acid will be found in the residuum.

Distillation. If fluid serum be distilled on the water bath, it affords an insipid phlegm, and a coagulum remains. On increasing the heat, it intumescs greatly, and produces carbonic acid gas, liquid and fixed ammonia, and a thick empyreumatic oil; a large residual coal remains, which is with difficulty reduced to ashes, containing common salt, carbonat of soda, and phosphat of lime.

It's component parts. It appears from the preceding experiments, that the serum of the blood is the albuminous part of it, and that it consists of albumen, a little gelatin, sulphur, muriat and carbonat of soda, and phosphat of lime. It is said, that the gelatin is the acidifiable basis which may be changed into malic and oxalic acids, but the albumen is the body that by dry distillation affords oil, and is chiefly distinguished on account of it's property of coagulation by heat, on which account the blood of animals is used in clarification.

2d. Coagulum or clot. This has likewise been called the *Craffamentum*. It is composed of two parts, which appear to have been partially separated by a spontaneous action, but which may be entirely so by artificial means.

2. Red serum. If the coagulum be well washed in cold water, the red part is dissolved by it, to which it communicates it's colour, and there remains a white fibrous substance which is the *fibrin* of the blood. The water thus tinged by the coagulum contains in reality all the colouring matter of the blood, and since when chemically examined, it proves to be the same as the white serum, except it's containing a great deal of iron, it may be called, in order to distinguish it from the other, the *red serum*. This iron is to be separated from it several ways, by incineration, or by reagents.

3. Fibrin. The fibrous part of the blood, or fibrin, having been

Difference
between it
and white
serum.

well washed off the red serum or colouring matter, is perfectly tasteless, and of a white colour. It's properties.

It is insoluble in water.

Exposed to a moderate heat, whether by boiling or by other means, it becomes hard; and if this exposure be sudden, it shrinks up like parchment.

Caustic fixed alkalis only dissolve it by the acid of ebullition, and caustic ammonia has no effect upon it.

Acids dissolve it, and nitrous and azot gases are extricated during the solution, and it is precipitated from them by water and alkalis, in a changed state.

On distillation in the dry way, it affords much aerated ammonia, and a very thick fetid and ponderous empyreumatic oil. The residuum, which is not very bulky, is compact, heavy, and easy of incineration. The ashes are very white, and contain neither soda, neutral salts, nor iron, but they afford pure lime, and phosphat of lime.

Exposed to a moist atmosphere, it very readily putrefies, swells, and affords a good deal of ammonia.

In inflammatory diseases, it is partly separated in the blood, and covers the coagulum in the form of a yellowish tough cuticle, commonly called the buffy coat of the blood.

Hence it appears that the blood is capable of being separated into three parts: 1. The white serum. 2. The red serum; and 3. the fibrin. Of these the white serum exists in the largest proportion, then the fibrin, whilst the red serum forms the smallest portion; but they vary in their proportions, according to age, &c. Proximate parts of blood.

If these three proximate parts be reduced to the utmost analysis of which chemistry is capable, the remote component parts consist of oxygen, azot, hydrogen, carbon, sulphur, phosphoric acid, soda, lime, and iron, to which may be added the peculiar aroma of the blood. Remote parts. It is to these few ultimate and indivisible parts that the

analytical science has been able to reduce this rich and wholly animalized fluid, which appears to be the primitive principle of all animal substances, and the common origin of all the animal solids and fluids; and since it conveys, during it's circulation through the vessels of the system, the principle of life to every part, which on being deprived of it dies, and becomes subject to the laws of spontaneous decomposition or putrefaction; the ancients were right in their assertions, that the blood was the vital fluid.

Having given a general view of the nature of the blood; of it's spontaneous separation into it's proximate component parts, and the effects that the chemical agents have upon them, it will be necessary to trace the outlines of it's history, and the chief experiments of the principal authors who have enriched the subject by their discoveries.

Ancient
analysis.

The ancients were of opinion, that the vital fluid or blood, which of all the animal fluids is the most universally distributed throughout the body, was a composition of the other animal matters; and Hippocrates, perhaps, from it's resemblance in colour to that of the muscles, called it running flesh; but they had not supported their conjecture by any chemical analysis, and it would have remained as a mere fanciful opinion, had not modern experiments ascertained, that the ancients were not very far from having asserted the truth. Before the time of Rouelle, very few chemical experiments had been made upon this fluid, and those by no means satisfactory. With respect to the changes it underwent on exposure to heat, they procured by distillation a water which they called *phlegm*. Vieussens found this phlegm to have very little odour or flavour, and Homberg having procured fourteen parts from sixteen of blood, thought that his experiments proved; on being compared with others, that

By distilla-
tion obtain-
ed phlegm.

this proportion of water was much less in plethora, gout, and scurvy, and increased in consumption, and a phlegmatic temperament. On continuing the heat, Boyle obtained an oily and reddish fluid, of a bitter savour, and manifestly urinous nature, to which he gave the name of *spiritus sanguinis*, which consists according to him of vo- Spiritus sanguinis. latile alkali dissolved in the above phlegm. He got rather more than six parts from twenty-four of blood. Grew obtained, after this spirit, *sal volatilis* in a solid state, of a Sal volatilis. white colour, a strong and penetrating smell, and effervescing strongly with acid liquors. According to Needham twenty ounces of the extract of blood contain about two drachms of it, whilst Verduc got one part from fifty-two of the extract. With this salt, but somewhat later, Boyle obtained a yellow oil, called the *oil of blood*, and by a Oil of blood. strong heat a pitchy oil that effervesced with acids. This oil was supposed to arise from the fat part of the blood. From 179 parts, Vieussens obtained four parts of this oil. The remainder, after this exposure to heat, was a splendid, light, spongy, black dreg, of a saline and bitter taste, of an inflammable nature, which Helmont and Boerhaave called the *coal of the blood*, others the caput mortuum; this Coal. they found to contain earth, marine salt, fixed salt, oil, and a very heavy oil which was evident from the deflagration, and reddish ashes composed of salt and iron remained behind. Hales likewise found an *aerial fluid* in Aerial fluid. blood, forming the 33d part of it.

With respect to the action of reagents on blood, it Action of reagents. was asserted by Boerhaave and Schwenke, that vegetable acids made it thinner; and by Eller and Courten, that fossil acids made it thicker or coagulated it. According to Boyle, alkalis rendered it more fluid, hence the necessity of taking acids to counteract its fluidity; Quesnai, on the contrary, thought they thickened it. As to the neutral salts, Stahl asserted that nitre coagulated blood.

Neumann in his examination of this fluid obtained similar results by distillation to those of his predecessors, viz. an urinous spirit, a concrete salt and an oil. Lewis, who examined it more minutely after evaporation and inspissation, found the exsiccated blood to be soluble neither in acid nor in alkaline liquors, that it communicated some colour to water and spirit of wine, and that it was more particularly acted upon by dulcified spirit of nitre. In his examination of recent blood, he found, that it was coagulated by the mineral acids, and by most of their combinations with earthy and metallic bodies; whilst vegetable acids and solutions of neutral salts produced no coagulation: that it's fluidity was increased by alkalis both fixed and volatile, by which it was preserved from coagulation: that the serum is not so much disposed to putrefy as the crassamentum: that it is somewhat more difficultly congealed by cold than pure water: that it coagulates by a heat a little greater than that of the human body: and that both this coagulum and the inspissated serum are very inflammable in the fire, and insoluble in water or spirit of wine, in acids or alkaline liquors.

Instead of making, however, any progress in the analysis of this fluid, the attention of philosophers was taken up in examining it's texture by means of the microscope, and a variety of opinions was the consequence, which will be found in the article *red particles*.

Rouelle published his work in 1773, and since this work appeared to the present time there is perhaps no fluid in the animal body, that has undergone such a variety of investigation, and been submitted to more experiments than the blood.

As the microscope was found to be of little use, chemical agents were resorted to. After having treated this fluid by distillation, maceration, fermentation, &c. che-

chymists had recourse to other methods. At first, the saline taste of blood made them presume that it contained some kind of salt, but no one could account for its coming there. The first idea was, that its salt or salts were introduced by means of the aliments perfectly formed, but from want of knowledge, no one suspected that nature was able to produce them in the animal as well as she had done in the vegetable kingdom: in the determination therefore of these salts the opinion of chemists was for a long time divided. Some supposed that the salt was the muriatic of foda; others pretended it was an alkali; and some even doubted of the presence of these salts, since those who admitted them, had obtained them only from the residuum of combustion, during the last effort of the fire to which the blood had been exposed, whence they concluded that they were the products of combustion, and not component parts of this fluid.

There were some chemists who went even farther, and supposed that an acid as well as an alkali existed in the blood. Amongst these particularly was Homberg, who asserted that this acid does not arise till towards the end of the distillation.

However fanciful the supposition was of its containing an acid, it appeared however, and more particularly from the investigation of Haller and de Haen, that different saline matters existed in this fluid. It was particularly to be observed from that of de Haen, that the water in which the coagulum had been washed gave evident traces of an alkali, and that exsiccated blood effervesced with acids, but it seems that the two chemists doubted of its existence. "Not one experiment," says one of these celebrated men, "is there to prove that there exists pure and disengaged salt in the blood, not one phenomenon characteristic of acid or alkali." It therefore remained to determine after the slight vestiges

of an alkali, of what species it was, in what quantity it was present, and whether it existed in a free or united state : this was effected by Thouvenel, but more particularly and satisfactorily by Ronelle.

Rouelle.

Having made the observation, that not only the aqueous part of the blood or serum, but the water of all dropscical parts possesses the same properties as the white of egg, of being coagulated by most acids as well as by a boiling heat ; likewise of uniting with water and changing the blue colour of violets to a *green* in the same manner as if a little alkali had been put into the water ; Rouelle concluded, that as the water separated from blood by distillation had no effect on the syrup of violets, except after having been kept some time, the property of changing the vegetable syrup did not proceed from any alkaline nature of the serum, or from it's volatile alkali, as some writers had supposed, but from a real disengaged fixed alkali. He supported this assertion by the properties of the more or less coloured mass remaining after distillation of blood. This which is pulverisable, and resembles externally a glue, but differs from it by being difficultly soluble in water, is found in time to have it's surface covered over with a crystallized salt, whilst the mass has regained it's tenacity by attracting moisture from the air. But he proved by experiment that the blood contained this uncombined alkali ; for on taking a quantity of serum either of the blood or from a dropsy, adding to it twice as much distilled water, and then mixing a little vitriolic acid with it and distilling it to dryness, he found, that on adding some boiling water to the remainder, and saturating the acid liquor, or rather the superabundant vitriolic acid with chalk, a real *Glauber's salt* was obtained. Instead of the vitriolic acid he used distilled vinegar, and the consequence was acetated soda. Hence the serum contained mineral alkali. In 1776 Rouelle published some other ex-

periments on the saline matters which the blood contain. They were made on that taken from different animals, such as the human, the ox, the horse, the calf, the sheep, the pig, the ass, and the goat. In these, he proves, that the calcined ashes contained in the blood of a healthy person afforded natron or mineral alkali, common salt, digestive salt in small quantity, an animal or calcareous earth, iron and a coal. He found that these were in various quantities, 28 or 29 parts of alkali to 16 or 17 of the neutral salts, whilst the animal earth formed the 10th part, and the quantity of coal was very inconsiderable. That on distillation and crystallization of the ashes, the common salt was first obtained, then the digestive, and afterward the natron or basis of common salt, and that the proportions of these were never the same in every sort of blood. Such are the experiments of this celebrated chemist on the serum of the blood, by which he for ever fixed the opinion of it's containing salts, such as soda and the muriats of potash and soda.

After Rouelle, the next chemist of any consequence is Bucquet. He communicated his experiments to the Academy of Sciences, amongst which are some interesting observations upon the different alterations the blood undergoes in it's spontaneous decomposition. According to this chemist, the coagulation of the *serum* or lymphatic part of the blood is not occasioned by the loss of it's aqueous part or by exsiccation, but is produced by the peculiar action of heat. He found that the water of distillation was at first tasteless, and did not affect syrup of violets; yet that it was not pure, but contained animal matter, since it became putrid in time, and changed the syrup to a green from the volatile alkali that was extricated. He found that on distilling the exsiccated serum it afforded a volatile alkaline spirit, fixed volatile alkaline salt in large quantity, and an empyreumatic oil, the

greater part of which sunk beneath the spirit. The remaining coal was light and spongy, and nearly filled the belly of the retort, and afforded a great deal of common salt and fixed mineral alkali. It was difficult of incineration, and contained an uncommonly small quantity of iron when the serum was free of any red part. He likewise found that the serum mixed in all proportions with cold water. If poured into boiling water one part was coagulated, whilst the other formed a kind of union with the water; he does not however think it was a perfect solution, for it remained white and somewhat milky, and could not be rendered clear by repeated filtration. If boiled, it swelled, and a pellicle arose on it's surface as is the case upon milk, and the addition of acids or alcohol coagulated those parts that prevent it's transparency.

It was strongly disposed to putrefaction, for having exposed a little of it to the air it became putrid in so short a space of time, as to prevent his being able to determine whether it had previously undergone the acetous fermentation.

From other experiments made upon it, it appears, diluted acids coagulated it, and by filtration a fluid was separated, which was easily dissolved by the concentrated nitrous acid after having been first coagulated by it. This solution was accompanied with a strong effervescence, and the dissolved part was precipitated by water.

Alkalis did not coagulate the aqueous lymphatic part of the blood, and even the caustic volatile alkali easily dissolved it when coagulated. This solution was decomposed again by any of the acids.

The neutral salts, whether with an alkaline or earthy basis, had no action on this fluid part; but almost all those with a metallic basis caused a considerable precipitation.

With respect to alcohol, it has been already observed

that the second part, even that which unites with water, is coagulated by it; but it is a curious circumstance that the same coagulated part is capable of again being dissolved, and in pretty considerable quantity, in water, which is not the case with that which has been coagulated by acids.

The analysis of the serum being once known, it remained to examine the coagulum, the red colour of which had given rise to much discussion, and since the investigation of the red particles forms an æra in the history of microscopical observation, it is necessary to give some account of their examination.

The discovery of the red particles in the blood was made towards the end of the last century. Red particles, Lewenhoeck. Lewenhoeck was the first who, having exposed the leg of a frog to the lens of a microscope, affirmed that the living blood consists of a number of red globular particles swimming in a large quantity of a transparent liquor. Elated with this discovery, he enjoyed himself in the regions of fancy, and imagined that each of these globules was composed of six smaller ones packed together, that while the six continued to adhere, their colour was red, but being separated, they became yellow and formed *serum*. His imagination carried him further, and he pretended that each of these serous globules consisted of six smaller ones, which when separated formed a more subtle and penetrating liquor than the serum itself. This theory, wild as it may seem, gained many admirers; it was even acknowledged as founded on facts, served to advance other theories, and gave rise to elaborate calculations, which now only serve to amuse the curious.

The great confidence which had been given to microscopical investigation invited other philosophers to examine the blood, and about the middle of the present century Father della Torre, on examining the red particles, found them to be of an annular figure, with a perforation in the middle, Father della Torre.

and the ring itself to be formed of several joints. The wonderful degree of magnifying power, however, which the lenses he made use of were said to possess, rendered the accuracy of his experiments doubtful, and some of them having been examined by the Royal Society, who failed in making so successful an application of them, the credit of this philosopher's discoveries rested on his own evidence.

Hewson,

To Father della Torre succeeded Hewson, who very carefully pursued a similar rout. He found, contrary to Lewenhoeck, that the red particles of the blood, when examined by the microscope, were flat in all animals, and consequently improperly called *globules*, and that they were of very different sizes in different animals. In man they are small and flat as a shilling, with a dark spot in the centre. In order to examine them with more distinctness, he diluted the blood with fresh serum, which precaution having been omitted by his predecessors, they were only able to see them very indistinctly. As to the black spot, the particles of the human blood being very small, he found it difficult to determine, whether it was a perforation, as some imagined, or not; but he discovered in the frog, where it is six times larger than in man, that it was a little solid body contained in the middle of a vesicle. Instead therefore of calling the particles of blood red *globules* he thought red *vesicles* would be more proper, each particle being a flat vesicle with a little solid sphere in it's centre.

He found the blood of all animals contained vesicles of this sort. In the human and that of quadrupeds there are millions of them, and they give it the red colour. In insects they are white and less numerous in proportion. He found that their flat shape was alterable by mixing them with different fluids, and that it is by a determinate quantity of neutral salt contained in the serum, that this

fluid is adapted to preserve them in their natural flat shape; for if mixed with water they become round and are perfectly dissolved, but on the addition of a little of any neutral salt to the water, they remain in it without any change of form, or without solution; hence Hewson suspected the shape of these particles to be a circumstance of some importance. He found that on diluting the blood of a frog or toad, with the serum of the human blood, the particles which are large became flat, as is the case in the vessels of that animal, whilst a little water first made them round, and then began to dissolve them; a neutral salt gave them their flat shape, but if this was not added, the vesicle was gradually dissolved by the water, and the little sphere was left alone. He found that the particles in the blood of insects, whether aquatic or earthy, were similar in figure to that of other animals, but differed from them in colour. Such are the microscopical observations of this celebrated physiologist.

A more laborious investigation of the figure and size Cavallo of these red particles has been made by Cavallo. He defends the falling credit of Father della Torre both with respect to the instruments he used and his experiments. He does not find that any lenses or globules of very great magnifying power were used before the time of that philosopher, who constructed them of wonderful minuteness, and at the same time clear and distinct, and it is from the great difficulty in their construction, and in their use as magnifiers, that he attributes the causes why so few have repeated della Torre's experiments, and why most of them have been unsuccessful, which want of success has thrown such suspicions on his experiments and observations. Cavallo after much trouble succeeded at last in constructing a few microscopical globules after his method, and having repeated his experiment on these globules with an apparatus made expressly for such delicate work,

he found the description that della Torre has given of the appearances to be very accurate, although his conjectures may have been sometimes crude or mistaken.

From the experiments of Cavallo it appears, that the mean size of the red particles differs very little in persons nearly of the same age; that they differ somewhat in the same person; and that their figure is not very circular: but this deviation from the circle is not such as a flat circular surface would assume in it's different inclinations to the axis of vision, for the flat circular surface (according to the rules of orthographic projection) must appear either circular, or elliptical, or as a straight line, whereas this experimentalist never perceived these red particles to form straight lines, *i. e.* edgewise, and the elliptical figure they sometimes assume is by no means regular.

In an adult person he found the diameters of the red particles from 0,0003 to about 0,0004 parts of an inch, and seldom smaller or larger. If therefore the smallest of them were set in a row, 3334 will be equal to one inch, and if the larger, about 2500.

When these particles are magnified more than 40 or 50 times, and less than 80 (in diameter) they appear like colourless transparent spots, enclosed within dark circles.

When magnified more than 80 and less than 160, a dark spot appears in the centre of each, resembling a dot made on paper with ink. He found that if the reflector that illumines the particles, instead of being placed before the object, be set on one side of the axis of vision, so that the light may be obliquely thrown on the object, one half of the dark circle of each particle disappears, which is that on the side opposite the reflector. At the same time, the central spot appears to change it's place. When the particles are magnified about 200 times, the central spot appears converted into a circle enclosing a transparent space. The diameter of this inner circle equals half of

that of the external one, but the proportion of these diameters, or the size of the internal circle, may be brought to increase or decrease by the least alteration of the distance between the object and the lens, and by the same means the space within the inner circle may be rendered clearer or darker than that between the two circles. The position of the inner circle is changed by the direction of the light: for if the particle of blood be viewed through a microscopical globule of glass directly facing the flame of a candle, without the intermedium of any lens or reflector, the inner circle will appear concentric with the outer one; but if the candle be moved a little to one side, that the light may fall obliquely on the particle of blood, the inner circle will be observed to move towards the opposite side, and to acquire an elliptical shape.

When the particles of blood are magnified above 400 times, an imperfect image of the candle, which is placed before the microscope, may be seen within the inner circle of each particle. Through a glass globule of 0,018 of an inch in diameter he has seen the red particles magnified about 900 times, in which case the image of the flame of the candle could be seen within the inner circle of each particle very clearly, at least so as to show to which side the motion of the air in the room inclined it. Although the magnifying power was so great, yet the annulus or space between the two circles did not appear to be divided, except some accidental fractures sometimes seen in a few of the particles.

From these observations, this philosopher thinks that the red particles of the blood are not perforated, but that they are globular, and composed of some uniform substance much less transparent than glass. They likewise show that Hewson's idea of their containing a central body, or nucleus moveable within the external shell, arose from the apparent change of place which the

various direction of the light produces on the central spot or inner circle of each particle.

On the supposition of these red particles being globular, he expected to find that globules of other transparent matter would exhibit the same appearances, and his expectations were in great measure verified. The shades of difference he observed between them were: First, that the glass globule showed a distinct, whilst the red particle showed an indistinct image of the candle: Secondly, that the inner circle of the globule is much smaller in comparison with its external boundary than the inner circle of the particle is, compared with its external one: Thirdly, that the annulus is uniformly dark in the globule, whereas in the particle it is as clear or clearer than the internal surface.

On examining these particles in the living animal, if any thin and transparent part, such as the tail of a small fish, or the membrane between the toes of a frog, be viewed through a good microscope, the circulation of the blood through them is only perceived by the motion of these red particles, which follow each other at a greater or less distance, although in general, each particle seems to touch, or nearly so, the following one. They are never seen to run into each other and incorporate, and though not very hard, they are possessed of a certain degree of consistency and elasticity, for in passing through the very small vessels, they are frequently seen to assume an elliptical shape, whilst from the smallest vessels they are absolutely excluded.

By labour the red particles may be accumulated in a wonderful degree; thus, in hard-working people they abound, and by the exercise of particular parts the same takes place, as in the wings of those birds accustomed to fly, and in the legs of those accustomed to walk a great deal. They are numberless in health and in all strong creatures,

whilst in diseased and weak animals they are in small quantity.

Cavallo, on continuing his experiments on the red particles, found that they lose their shape and are dissolved in certain fluids, that this does not take place in the serum of the blood or in urine, except when left in these fluids for several days, or when these fluids are diluted with water. But water alone he found to be a powerful and almost instantaneous solvent for them, although it may be deprived of this property by the addition of common salt, or nitre, or of any other neutral salt, as well as by the admixture of a very small proportion of the vitriolic acid. He found that the marine acid, when much diluted with water, had no solvent effect upon them, but it's action deprived them of their colour. Vinegar is likewise a powerful solvent, but not equal to water. He found that when once they were dried or dissolved in water, they were not capable by any means of resuming their former shape: and it appears that their formation even in the animal body is accomplished with great difficulty, at least much less expeditiously than that of the other component parts of the blood; for in those animals that have lost much blood, although the sanguiferous vessels are speedily filled with red blood, yet it continues thin and pale for a considerable time, and when examined by the microscope, few red particles are to be found in it. This ingenious philosopher does not attempt to offer any further conjectures respecting the nature and construction of these particles.

The next circumstance to be considered is their colour. ^{Their colour.} It was supposed by the ancients that there was only one kind of blood; thus Erasistratus taught that the veins contained the blood, whilst the arteries only contained a spirit. Galen, however, speaks of the blood on one

side of the heart being more florid than on the other, which florid blood was the arterial. The celebrated Harvey, and the first believers of the circulation, were of opinion that there was no difference between the arterial and venous blood, either in colour, density, or in their elements. Some time after Harvey, when the subject of the redness of the blood came to be investigated, it gave rise to many disputes. Some pretended, as the microscopists, that it arose from the reunion of a certain quantity of globules, and the colour disappeared on their being divided. Hoffmann thought he had found the cause in the union of the alkali with the spirituous matter, which he supposed to exist in the blood. Other chemists attributed it to different salts, and it was observed by Senac, in his work on the heart, that salts might augment its red colour without increasing it. After making various observations, he relates that the arterial blood is always of a more red and lively colour than the venous; that this colour is the more exalted as the action of the arteries is the more violent; that in young people it is more red and high coloured than in old: and these observations were sufficient for some authors to find the cause of the redness in the action of the vessels, in the multiplicity of the globules, and in the separation of the lymph; but the numberless objections to which these theories were exposed soon made it necessary to form more satisfactory explanations.

Several old authors had observed that blood, when agitated in the open air, immediately acquired a redder colour than before; and this act, which till now had not appeared to be very interesting, immediately fixed the attention of physiologists, and there was reason to believe that it might lead to the cause. Hewson, after many careful experiments, announced, although it had been done before him, that the combination of the air

with the blood was sufficient to colour this fluid. The only difficulty now was to indicate what body it was in the blood, that the air principally fixed upon in order to become the colouring principle, and this difficulty was soon taken away on recollecting that the blood contained iron. This discovery is due to Badia, who is said to be the first that found iron in this fluid, and all opinions united and agreed to consider the combination of iron with the air as the cause of the red colour.

Menghini is the chemist who appears to have the best followed the constant and uniform track of nature, relative to the distribution of this metal in blood, the presence of which deprived of it's colouring part, is a fact equally important as the discovery of a free alkali. Some chemists supposed, and amongst these were Geoffroy, that this metal being found in the ashes of blood was the effect of the fire; others, as Lemery, pretended that it was already formed in the blood, and that the fire only exposed it by destroying the bodies with which it was mixed; whilst others believed it to be the production of the vessels in which the combustion of the blood had been made. Amidst these doubts and conjectures, Menghini continued to separate the iron without the assistance either of calcination, or any instrument the influence of which might be suspected: the method he made use of was to dry some blood by a stove heat, and he found that the powder obtained, when exposed to the loadstone, became very sensible to the magnetic impression. He found that there was a more considerable quantity in the human blood than in that of quadrupeds, that there was less in fish, and still less in that of birds: and he concludes, that in the animal body the blood is the only true receptacle for it, and the experiments and observations which have been made, since those of this learned

Iron.

Experiments
of Menghini.

Italian chemist, have confirmed and developed the truths that are established in his works.

Kouelle had likewise paid particular attention to the examination of the *coagulum* of the blood; but a premature death interrupted his labours, and deprived the science of chemistry of one of its most distinguished votaries. This examination, indeed, required both physiological and chemical knowledge, and Bucquet, who appears to have united both with a great deal of industry and perseverance, is the next author to whom we are to look for information.

Bucquet. This physician, whose experiments on serum have been already related, has likewise made the *coagulum* the subject of his researches.

The coagulum, according to this chemist, is composed of two parts, the *fibrous matter* and the *sanguineous globules*. He considers the fibrous matter as having the greatest tendency to become concrete of all the circulating fluids, and he thinks, that when once coagulated, it cannot be dissolved by water. The smallest degree of warmth is sufficient to harden it in a peculiar manner, and before it has even lost its moisture. It then immediately becomes of a dirty gray colour, diminishes in volume, and becomes contracted like parchment. It gives on distillation nearly the same products as the serum, but the remaining coal is much thicker and more solid. If it be well washed before distillation, the coal contains neither common salt nor mineral alkali. It is much easier incinerated than the coal from the serum, and its very white ashes contain neither salt nor iron.

He found that this fibrous part was not to be dissolved by boiling water; but became rather hardened and of a gray colour. It is likewise soluble neither in alcohol, oils, yolk of egg, alkalis, nor in the caustic volatile alkali, which so readily dissolves the coagulum of the serous

part; but is easily dissolved by all the acids, even by vinegar, and it may be again separated from them either by water, or still better by alkalis. These properties are very curious, and according to this chemist, resemble most of the properties of the glutinous part of flower, and of the caseous part of milk.

With respect to the red part of the coagulum, or red globules, they may be easily separated from the fibrous part by simple lotion, and the transparency of the coloured liquor announces a perfect solution of them. In this state he thinks it differs very little from the serum, except in colour. It is like the serum coagulated by heat, by acids, and by alcohol, and is soluble in volatile alkali, and affords the same products by distillation. Its coal is likewise equally light, contains common salt and mineral alkali, and is of difficult incineration. He has however observed that the cinder or ashes have their brown red colour from the iron they contain; it resembles the colour of the saffron of Mars, and is in large quantity. In his idea, therefore, of the coloration of blood, he has adopted the sentiment of Menghini. He also believes that the want of colour, or the decoloration of this fluid in certain chronic diseases, is owing to the absence of this metal, and that the colour is again to be restored by the use of martial preparations.

Although the ingenuity of chemists, particularly of ^{Sage} Bucquet, had made great progress in the examination of the blood, they had not found out under what form it was that the iron existed in it, nor was there any more certainty to be collected from the idea of Sage, who conjectured that it was present in a state of combination with the phosphoric acid.

At the time Bucquet published his experiments on this important subject, a revolution was preparing in the science of chemistry, which, by adding new ideas on the

composition of bodies, to those that had been already received, must necessarily conduce to the discovery of new means to examine them. It was in consequence of this event that chemists began to be convinced, that the fluid products obtained in the receivers, by distillation, were not alone deserving their attention; but that, to gain a more perfect knowledge of the component parts of bodies, it was likewise necessary to direct their examination towards the volatile and aerial parts, which hitherto had escaped their observation, or, at least, had been very little attended to. The knowledge which had been attained by the promoters of the new chemical doctrine, respecting the composition of the atmosphere, and the discovery of new gases, was the principal means which some chemists made use of to explain certain facts which occurred from the examination of the blood; and they more particularly applied it in the explanation of the cause of it's red colour, as well as of several other properties that characterize it.

Having determined, pretty exactly, the component parts of the atmosphere, the next circumstance to be attended to, previous to the explanation of the phenomena which the new method of examining bodies offers, was to know how this aerial fluid acted during respiration, which may be found, in detail, at the article *respiration*.

During this process it was said that one part of the oxygen, or vital part of the atmosphere, combines with the venous blood, and changes it's colour to a vermilion; a second portion of the oxygen unites with the carbon contained in the carbonated hydrogenous gas of the venous blood, and forms carbonic acid gas; a third part unites with the carbon of the mucus of the lungs, and this part, likewise, forms carbonic acid; a fourth

part combines with the hydrogenous gas of the blood, and forms water, which exhales during expiration; with respect to the caloric, which was looked upon as a material substance, one part of it, which the decomposed vital air contains, remains united with the oxygen; another part of the caloric enters into combination with the carbonic acid, to form a gas, and the third part produces the temperature to form the water, by the combination of the hydrogen and oxygen gases.

The first chemist who has enlarged our views on the nature of the blood, and who examined it according to the principles of the new system, is Fourcroy. This celebrated chemist has opened a new rout on this subject, and he begins his investigation at the moment this fluid flows from the vessels.

He found that, on agitating pretty briskly all the parts of the blood, as it comes from the vessel of an animal, and, for some short time after, it's coagulation is prevented; the only substance that separates is a spongy matter, of a flocky appearance, which swims on the surface. As blood is used in several of the arts, this method is used by the butchers previous to their selling it.

He found that blood, after having been drawn from the body of the animal, remains at 20° of the thermometer. At the moment of it's coagulation, according to this chemist, a quantity of caloric is disengaged, which, by raising the temperature 5° , makes the thermometer be at 25° .

Agitated blood, the principles of which have been prevented from separating, on cooling coagulates at 55° of Reaumur. During this coagulation, a number of air bubbles separate, which remain adhering to the side of the vessel; likewise in the internal part a number of cells is observed, which must have originated from some elastic fluid that had been disengaged. This coagulated mass has an odour and consistence very much resembling those

of the white of a boiled egg, and is of a grayish pearl colour. During this coagulation a milky or rather opaline coloured fluid is separated, which froths very much on agitation, and changes vegetable blues to green.

If this agitated blood be exposed to dephlogisticated air, in a very few hours it becomes of a more lively red than before. A few days after it had acquired a beautiful purple, and on agitation it changed to a beautiful scarlet red colour. Being still exposed, it became of a deep colour like that of the leys of wine, and it was with great difficulty it resumed it's former scarlet colour by agitation.

The air found to have arisen from it was carbonic acid gas, that had been formed from the carbon of the blood and the oxygen of the vital air. This blood on exposure to hydrogen gas, lost in a few days it's natural colour and brilliancy, and was brown; a few days afterwards it appeared to have separated into several parts by undergoing a decomposition, it had an oily aspect, and it's colour was purple resembling wine leys. These changes are attributed by this chemist to the absorption or disengagement of oxygen.

Exsiccated blood being put into a crucible and heated by degrees, it became at first softened and considerably puffed up; there was then extricated a great quantity of very fetid greenish yellow fumes, this was succeeded by inflammation, and the flame was white and manifestly oily. After the oil and ammonia had been formed and disengaged, there was a formation of prussic acid gas, easily known by it's odour resembling peach flowers, and it's property of precipitating iron blue. In about six hours the matter was consumed to four-fifths; it became softened a second time, from the saline and fixed matters it contained; and there arose upon it's surface a purple flame, accompanied with a very thick smoke that very strongly irritated the eyes and nose: this was phosphorus in a state of combustion, which had been formed by the action of

the carbon on the phosphoric acid. The residuum afforded no soda, which blood is known to contain, it having been volatilized by the excessive heat: but muriat of soda was found, and the oxyd of iron in part reduced; as it was attracted by the magnet; it resembled that from the Island of Elba. Exsiccated blood distilled in a retort, to which a pneumatic apparatus was attached, afforded at first a clear liquid, like water, then carbonic acid gas, and carbonat of ammonia, which appeared on the sides of the glass in the form of beautiful crystals; these were succeeded by a fluid oil, hydrogen gas, and an oily substance of the consistence of butter.

Besides the exact manner in which this chemist had de- Bile. composed blood by heat and collected it's products, whether in a fluid, fixed, or aerial and gaseous form, he made a very important discovery of the presence of the bile in it, which he assures us was the case. He first coagulated some blood by boiling it in distilled water, and the filtered liquor was of a green colour and odour perfectly analogous to those of bile; when evaporated to the consistence of honey, it's bilious odour became very strong, and it's green colour much deeper. On dissolving this extract again in water, it gave it a greenish colour and the property of frothing very much on agitation. This solution was precipitated by acids and alcohol; the precipitate formed by the last was gelatin, being soluble in cold water. The precipitation by acids was a real decomposition similar to that of bile when treated by these reagents. Hence this product of the blood procured by a simple process had all the characters of the bile of the ox, viz. it's odour, colour, bitter nauseous flavour, and it's manner of being acted upon by reagents. The discovery of this substance confirms one of the ideas of the ancients on the composition of the blood,

It is to the examination of the serous part of the blood Serum.

to which we are indebted for the discovery that Fourcroy made of the *gelatin* existing in this fluid, where Rouelle and the other chemists had only found albumen, alkali, and neutral salts. The existence of jelly in the blood, according to the writings of the ancients, was out of all doubt; but from the properties they attributed to it, it appears they confounded it with the lymphatic matter, which in some circumstances has really the same properties. De Haen was so convinced of jelly in the blood, that he could not conceive how this fluid could be without it, but it was necessary to give a demonstration of it, and Fourcroy engaged in it.

He found the specific gravity of serum to be eight times greater than water, that it is easily dissolved by water from zero to the temperature of 50 and 55, at which degree it coagulates. It was also coagulated by acids and alcohol, and heat was disengaged at the time. Serum put into a glass vessel of the thickness of one line, and plunged into a bath of distilled water, coagulated at 60° of Reaumur, the barometer being at 28 inches. When coagulated it was of a light grey colour; its consistence and odour very similar to the boiled white of an egg, and had in some measure its flavour. During the coagulation a liquor separates which is slightly turbid, this is *gelatin*; on evaporation, it becomes a trembling mass. In the blood this liquor is always clear, but in the serum always somewhat opaque.

¶ Serum when diluted with six parts of distilled water was not coagulated by the boiling heat, or by evaporation, to a greater than natural consistence; but a pretty firm transparent pellicle appeared on its surface resembling that on heated milk, so well described by Parmentier and Deyeux. Darcet and Scheele likewise knew that the addition of a certain quantity of water prevented the coagulation of serum by heat. Mixed with half or even with twice its weight of

water, it coagulates, and on evaporation carbonat of soda and marine salt are obtained; these salts it appears are but slightly embarrassed by the portion of gelatin and albumen that remain dissolved in this water, and when the liquor is strongly evaporated, they separate on cooling.

The circumstance that appeared to Fourcroy the most worthy of being recorded, was his being able to discover the cause of the coagulation of the albuminous matter by heat. Having observed that the white of the egg became thick in process of time by contact with the air; that an egg that had been kept a long time, so as to be able to have absorbed the air, was much sooner boiled or hardened than a fresh egg; and that the last never became so hard as an old egg; he concluded that the fixation of oxygen was the cause of this coagulation, and that a certain degree of heat was necessary to unite the albumen with the oxygen, the same as it is necessary in the combustion of all combustible matters, in the oxydation of metals, &c. It was in this manner that the thickening of the lymphatic liquids in the air, the formation of the white, thick, homogenous and concrescible pus in open wounds, and in ulcers of the lungs which admit the air, had been explained; but a direct experiment was required to remove all objections. Several drachms of serum were therefore mixed with an oxyd of quicksilver that had been precipitated by potash from the oxygenated muriat of mercury; and it was found that in about 12 hours the oxyd had lost its redness and was become black or grey, which announced a separation of the oxygen and a reduction of the oxyd, whilst in proportion as this took place, the serum was found to thicken, it was even very hard on its surface, and by agitation the whole became perfectly concrete and solid.

Having thus accounted for the coagulation of the albumen, the curiosity of this chemist was next directed to

compare the blood of the human foetus with that of the adult. He remarked that the blood which had been drawn a few hours from the umbilical cord of a newly born infant was coagulated. The serous part, which was very abundant had a red colour tinged with brown; it sensibly changed paper stained with mallows to a green colour; it coagulated at a heat of 55° of Reaumur, the barometer being at 27 inches 8 and $\frac{6}{10}$ lin.; but it was not so solid as that of the blood of the ox, and a great part of the serum remained uncoagulated. It was not white when coagulated, but being combined with a certain proportion of colouring matter, this coagulum had a brownish grey colour. The filtered liquor from this coagulated serum, diluted with distilled water, was not sensibly troubled by lime water, hence Fourcroy concludes that the serum of the foetus contains no phosphoric acid.

The coagulum was not so solid as that of the adult, it was of a deep brown red colour, hence it does not become so completely red as that of those who have respired; there only appeared to be some red threads which variegated the surface of the brown mass, so that it seemed to be veined with a purple red on a ground of a dark brown. This coagulum well washed with distilled water did not afford $\frac{1}{2}$ of fibrous matter. The wash exposed to heat coagulated, and the filtered liquor after having been evaporated to 14 showed no signs of the presence of phosphoric acid. From these experiments the blood of the human foetus differs from that of the adult in three remarkable properties: 1st. Its colouring matter has a deeper shade, and is not susceptible of receiving the splendid purple by the contact of the atmospheric air; 2d. It contains no fibrous matter concrescible on cooling, the thick and coagulated portion instead of it seems rather to approach to the gelatinous matter; 3d. It contains no phosphoric acid. It appears to this chemist, that the

first two characters, so different from those observed in the blood of young people and of adults, manifestly arise from the fœtus not having respired, the contact with the atmospheric air not having yet modified the nature of this fluid by the caloric it affords, and by the carbon it absorbs from it during the act of respiration. The great difficulty of procuring this blood in sufficient quantity prevented this chemist from pursuing the comparative experiments he desired, which are necessary to render it's analysis more exact. To this account of the investigation of the blood may be added the curious fact of this chemist having found real native prussian blue in the blood of a sick person, which on exposure to the air assumed the brightest blue colour.

Prussian
blue in the
blood.

Having described the principal part of the labours of the ancients and moderns on the analysis of the blood, to the time that Fourcroy placed the nature of this fluid in a new light, we proceed to give the details of the experiments of two of his successors, Parmentier and Deyeux, whose combined diligence and talents have enriched the subject with the most interesting facts and observations.

Parmentier
and Deyeux.

Parmentier and Deyeux commencing their investigation of the blood as it comes from the vessels, observed, that it differs very little at that time from what it is in the living animal, but it soon changes it's state, and the first alteration is manifested by the loss of it's fluidity, it's heat, it's odour, and it's homogeneity.

First
changes.

They observed that whatever is susceptible of altering the nature and properties of the blood has a singular influence on it's aroma or odour. To this may be attributed the more or less lively impression a person receives from this fluid as it flows from the vessels, or on entering a butchery, the floor of which is wet with the blood of a newly killed animal. This odour is sometimes so strong as scarcely to be supported, at least by some people, in-

Aroma.

ducing a disposition to syncope or an inclination to vomit.

Properties
of it.

This aroma or odorous principle of the blood had fixed the attention of the chemists, but the only circumstances known of it were, that it is soluble in water, and that the fluid which holds it in solution changes, and in a short time contracts a putrid odour. Presuming that these were not it's only properties, these two chemists endeavoured to investigate it further; and they conclude from their experiments that there is no spirituous or inflammable principle connected with the odorous part, as some authors have pretended; but that the deleterious quality which has been experienced upon respiring it in large quantity is of a peculiar nature, and essentially different from that produced by musket and carbonic acid gas; and that the means made use of to detect the presence of these last are insufficient, to establish the properties of the gas that escapes from the blood. On examining it's nature, they found the affinity of the odorous principle with the atmosphere to be inferior to that which it has for water, and that the last seized it with great avidity. They look upon it to be a compound body susceptible of change, that it's alteration is more sudden when assisted by a warm temperature, and that it is at the moment this change takes place that the disagreeable odour is perceived, which is not to be confounded with that which exhales from animal matter the putrefaction of which is complete, because the last contains ammonia.

In union
with atmospheric air.

With water.

Having examined this odorous principle in combination with the atmospheric air, they tried it when in solution in water. To procure it in this state, they distilled some venous blood newly drawn from the ox, on a water bath, and they obtained in the receiver a transparent colourless fluid, of an odour similar to what the blood exhales, and having a disagreeable nauseous flavour. This

newly distilled fluid was not affected by the ordinary reagents. Evaporated on the water bath it left no residuum, and on being kept for some time in a well closed bottle it became putrid, and lightly changed the syrup of violets green. This odorous water lost it's odour likewise at a degree of heat capable of making it simmer.

It is likewise soluble in alcohol, but the odour of this liquor is not at first very marked, it becomes however very evident on diluting it with water. Reagents have no effect upon it. With alcohol.

These chemists, from the above experiments, are of opinion that this odorous principle of the blood is analogous to the *esprit recteur* of plants, since both of them affect very sensibly the organ of smell, are volatile, are soluble in water and in alcohol, and their solution is not sensibly acted upon by reagents. The most remarkable and peculiar property of this odorous principle, is being subject to a quick decomposition, in which state it exhales a disagreeable and sometimes a putrid smell. They conclude however by observing that there is a complete analogy between it and other animal substances, since milk, bile, muscle, the Urine, &c. have each an odorous principle which serves to distinguish them, and the properties of which resemble those of the odorous principle of the blood. It is in this aroma that the first alteration of animal substances takes place, to prove which it is only necessary to observe what passes in the air and water which contain this principle in solution. Analogous to the spiritus recteur of plants. With other animal substances.

On repeating the experiments of Fourcroy, these chemists found in contradiction to the assertion of that chemist, that blood in a healthy state contains no bile, either in it's serum or coagulum. They allow, however, that it may perhaps be present sometimes in diseased blood, since it appears from some physicians, that the mucous and milky humours are known suddenly to quit No bile in the blood.

their organs to overwhelm the mass of blood; at the same time the numerous contradictions to be met with in books which treat of animal analysis, often arise from the experiments having been made on the substances in very different states, which they are known to undergo; an instance of which is in the urine, for in cold weather the first alteration in it is that of acescency, whilst in hot weather it is scarcely or not at all observed from the alkalescency that succeeds it. This shows how necessary it is, in order to obtain similar products from similar experiments, to have the substances upon which they are to be made always in the same state and under the same circumstances.

Serum.

Many physicians have endeavoured to determine by different experiments the quantity of serum contained in the blood. Some have pretended that it's quantity is nearly equal to half of the whole mass that comes from the veins of a healthy subject; others have affirmed that it forms only three quarters at most. From the experiments of Parmentier and Deyeux it appears, that the great difficulty of ascertaining this fact, as well as procuring serum in a state proper for chemical analysis, arises from the great variations it admits, in it's cohesion with the coagulum. To obtain this serum pure, *i. e.* with the colour that naturally belongs to it, it is necessary that the vessel which contains the blood be set in a place of repose, at least during an hour, as the slightest motion is able to affect and oppose the separation of this part. On repeated examination of the serum, these chemists found that it contained (as their predecessors had proved before them) water, albumen, gelatin, neutral salts, and mineral alkali or soda. But it remained to determine, whether these substances are in a combined state, or exist separately, each of them enjoying their respective properties. This question was the more interesting to determine, as

Rouelle, the only chemist that had been any ways successful, seems to have increased the incertitude of it by concluding, that the salts, and especially the alkali, were not combined with the other constituent parts of the blood. These chemists find it difficult to conceive how Rouelle could make such a conclusion, since it is unreasonable to suppose, that the fixed alkali in the serum, together with the gelatin and albumen, can remain by the side of these two substances and circulate with them, when experience proves that fixed alkali when mixed with them increases their solubility.

As a proof of this, if some dephlegmated spirit of wine be added to fresh serum, the mixture will become immediately turbid, and the albumen separated. If very pure alkali be poured on this albumen, it will be dissolved, and the water with which it shall be mixed, will be transparent.

To this it may be objected, that the proof of the fixed alkali not being combined with the albumen is, the serum changing the syrup of violets to a green, a phenomenon which ought not to take place, if the pretended combination existed. But it may be answered, that there is a combination of the albumen and gelatin with the fixed alkali, in the same manner as there is between oils and the alkali; and it is well known that the most perfect soap has the property of changing the syrup of violets green, and nobody certainly can doubt, but that the fixed alkali in the soap is combined with the oil.

It may perhaps be still objected, that any analogy between the pretended combination of the albumen in the one case, and the soap in the other, is so much less founded, as this last matter soluble in water is infinitely more so in spirit of wine, whilst the solution of the albumen by the fixed alkali is not soluble in spirit of wine, this fluid decomposing it. To this objection these che-

mists look upon the answer to be very easy. In establishing an analogy between the combination of oil and alkali forming the soap, and the combination of the fixed alkali with the albumen, such as they suppose it to exist in the serum, they are far from pretending that these two orders of combinations ought to have a perfect resemblance; for it is well known, that in order for the analogy between two bodies compared together to be complete, it is necessary, that the parts employed in their formation be absolutely the same; without this condition there will be always a sensible difference, which however, in other respects, will not prevent the existence of an evident analogy. Thus for example, if it be said that the muriatic acid forms a salt with fixed alkali, and that this same acid likewise forms a salt with calcareous earth; it is not to be supposed, that a perfect analogy is intended to be established between these two salts, since one of them is always deliquescent, while the other easily takes a concrete form: but it is not less true that there exists a similitude in the manner in which this acid combines with the alkali and the calcareous earth; hence in this respect there is an analogy between the two salts. It is the same respecting the combination of the albumen with the alkali, some of the properties of which differ from those of the soap only by the constituent parts of these two bodies not being perfectly alike. It therefore appears to be proved, that the fixed alkali found in the serum is in a state of combination with the albumen, and that it does not circulate in the blood in a free and isolated state.

Fixed alkali
combined
with the al-
bumen.

The muriats
of soda and
of potash are
in a disengaged
state.

This, however, cannot be supposed to be the case with the muriats of soda and of potash that exist in this fluid. These salts, that have no tendency to combine like the alkali, may be looked upon to be in a disengaged state in the serum, hence it is only with respect to these that the opinion of Rouelle ought to be adopted.

From the very strict examination which these chemists ^{Sulphur} made of this albumen, they found that independent of the fixed alkali combined with it, it likewise contains sulphur, and this discovery is one of the most curious and important that has yet been made in the analysis of the blood.

To show the presence of sulphur, the albumen must be ^{How obtain-} heated in a silver vessel, and being perfectly dry, be made ^{ed.} to undergo a degree of heat greater than that of boiling water, when the part of the vessel in contact with the matter will soon be seen to lose its metallic splendour, and become of a black colour, resembling that which sulphur produces when heated upon a silver plate. This sulphur may be obtained apart. For this purpose, some of the albumen is to be triturated in a glass mortar, with a few drops of a well saturated solution of silver; on digesting this mixture a certain time, then heating it after diluting it with water, some greyish threads will be observed, which, by degrees, will become black, and will form at the inferior part of the vessel a precipitate, from which it will be easy to extract the sulphur in the ordinary way. In short, if fixed alkali be boiled with albumen and water, a liquor will be obtained, which being filtered and mixed with distilled vinegar, exhales an hepatic odour, susceptible of changing the colour and splendour of silver.

With respect to the presence of this sulphur in the serum, and its origin, different questions may occur. Is it the product of animalization, or rather according to these chemists, must it not be attributed to the decomposition of a body which contained it already formed? Without engaging in any discussion that might lead from the principal object, it is only necessary to observe, that the albumen of the blood is far from being the only animal matter in which sulphur is to be obtained, since it

has been extracted from the white of the egg; it is suspected to exist in bile, and it is present in great abundance in the substance of the brain. It appears to these chemists very probable, that the sulphur which is found in the greater part of the animal fluids is as essential to them as their neutral salts, and since it is constantly found in them as well as in serum, it ought to be regarded as one of their constituent parts.

Gelatin.

Of all the parts of the serum, the gelatin which it contains more particularly engaged the attention of these two chemists. It has been before observed, that Fourcroy had made it the object of his examination, but the experiments of this learned chemist being repeated, and only affording insufficient results, new experiments were necessary to procure it in it's perfect state, which was

**Method of
obtaining it.**

effected in the following manner:—About ten ounces of very pure serum were exposed to the heat of the water-bath in a glass basin, and instead of withdrawing the vessel immediately after coagulation of the lymphatic part, as is the custom, it was permitted to remain for half an hour longer. On examining the matter, it was of a white colour, and the different parts that touched the internal sides of the vessel were strewed with small cells that contained a yellowish matter. On the surface of the coagulated lymph was a thick, yellow, transparent substance, having all the appearance of a jelly; half an ounce of this being separated, and submitted to different experiments, presented the following properties.

It produced the same effects as glue when taken between the fingers, or extended upon paper; it was of a mild flavour, was readily dissolved either by the saliva or by water; the last solution on being exposed to a humid and warm air, soon became covered with a mouldiness; in this state it had a somewhat acid flavour, and in time it became putrid. Another portion of this matter, exposed

in a warm place, became dry, and formed on the plate of glass, where it was extended, a transparent layer, as yellow as amber, which on being afterwards distilled on a naked fire, afforded the same products as the jelly of hartshorn. When mixed with caustic soda, diluted with water, it was soon dissolved, the solution was clear and transparent, but on attempting to separate it, instead of reappearing in the gelatinous state, it was only in the form of white flocks. Having repeated these experiments on the serum of the blood of many animals, these chemists were convinced of the existence of gelatin in the blood, and that it forms an essential constituent part of this fluid.

They likewise observe, that the gelatin separated in the above experiment is not the only part that exists in the blood. They think it more than probable, that another portion is combined with the caustic soda found in this fluid, by which combination it loses it's peculiar property of appearing in the form of jelly, and which accounts for it's not reappearing with this property in the serosity where it is thus dissolved. The gelatin therefore, which is manifest on the substance of the surface of the coagulated albumen is only that, which not having found a sufficient quantity of soda in order to be dissolved, naturally takes the thick consistence which belongs to it when it is not combined with a foreign body. This mode of reasoning is supported by the phenomenon observed on the addition of some caustic soda, that had been added to some serum : for on heating the mixture, gelatin was no longer obtained, one part of the albumen was also dissolved, and the coagulum, instead of being solid, only became of a soft and pulaceous consistence.

Part of it in
a combined
state.

It now remains to know, if the soda, the albumen, and gelatin, are in an isolated state, and circulate so in the blood without being combined ; or rather if the combi-

nation of one part of these substances only takes place when the serum is coagulated by heat, a circumstance difficult to determine.

Having already proved the existence of gelatin in the serosity, the next thing was to find out if the coagulum, as well as the fibrous matter separately examined, would equally afford gelatin.

The analogy of the fibrous matter with the muscular substance, gave them reason at first to suppose that gelatin would be found in it. For this purpose, one pound of fibrous matter was separated from the blood of a fresh killed animal by agitation, and boiled for about half an hour in distilled water. The liquor was then evaporated on the water bath even to three fourths: on cooling, it afforded no jelly, and exposed afterwards to the air in a warm place, it continued to evaporate without showing any gelatinous matter.

They were not more fortunate in their examination of the coagulum, from which the serum had been separated as much as possible.

Gelatin only
in the serum.

From these experiments, it would appear that the serum is the only part of the blood that contains gelatin, and that it is in vain to look for it in any other of the component parts.

Differs in
different
blood.

It was likewise discovered, that the gelatin is not constantly the same in the blood of all animals; in the blood of healthy people it is found to differ both in consistence, colour, and quantity; and equal differences are observed in the gelatin of the blood of diseased people. From the first observations which Parmentier and Deyeux made on this subject, they were in hopes of finding, that the state of the gelatin might be a means of discovering the nature of the disease: but experience soon taught, that they were deceived; for in people labouring under the same disease, some afforded blood the gelatin of which had a great deal of con-

sistence and was in large quantity; others blood of which the gelatin was much softer and in less quantity. In short, it would seem, that it is with the gelatin as with the fibrin and albumen, which are never identic in all individuals; that their peculiar state, their nature, and their quantity, depend on numberless circumstances relating to organization, which it is impossible for the chemist either to appreciate or indicate.

From the preceding experiments, the opinion of Fourcroy on the existence of gelatin in the serum of the blood has therefore been confirmed by these chemists, and there is reason to believe that this discovery may be a means of conducting the physiologist to the true theory of the formation of the muscular fibre.

Blood that is fresh drawn from the vein has it's surface commonly covered with a froth, a great part of which is dissipated as soon as formed. The blood insensibly loses in volume; and a thick substance is seen to form around the sides of the vessel that contains it, which proceeds to the centre; this consistence increases until the whole is in a state similar to a jelly. When the coagulum is separated from the serum in which it swims, it is tender and easily divided; internally examined, it presents a lamellated form, which appears to indicate a symmetric arrangement; the external part of the coagulum is of a lively red, whilst those parts of it not exposed are dark coloured.

The cause of the coagulation of the blood, when it is drawn from the vessels, the circumstances that attend, that accelerate, retard and suspend, or destroy this coagulation, have given rise to many disputes. It had been attributed to the cold the blood meets with out of the body, but Hewson proved that this was an erroneous opinion, and the same has been confirmed by Parmentier and Deyeux; for having received some blood in two bot-

Coagulation
of blood.

Various
opinions of
it's causes.

bles; one was plunged in water heated to 50° , the second in water at zero, and the third exposed to an atmosphere at 15° ; but the coagulum was formed at the same time, and in the same manner, in all the bottles.

According to Hunter, the coagulation of the blood takes place, although it be preserved at a degree of heat equal to that of the animal: that it goes on in the open air, in vacuo, or in a closed vessel. Neither repose nor agitation prevents it; and this coagulum abounds in the vessels nearest to a gangrenous part. During it's coagulation the blood does not increase in temperature, whilst all other bodies do in passing from a fluid to a solid state, but resists congelation longer than other bodies, and more so the first time than afterwards. This physiologist looks upon the coagulation of the blood to be analogous to the tonic contraction of the muscles which takes place after death, whilst the causes that deprive the muscles of this tonic force likewise deprive the blood of the power of coagulating. These causes are the absence or presence of the vital principle.

Not occasioned by air,

Some have pretended that the air occasioned the tendency to coagulation, and that if the blood be kept in a vessel hermetically sealed, the coagulation does not take place. To verify this assertion, Parmentier and Deyeux received some blood both from the veins and arteries of an animal into three small glass bottles of the same size; one was closed with a ground glass stopple, the second with cork, and the third was left open; but in all three bottles the coagulation was found to take place in the same manner, and at the same time.

or by neutral salts.

Neutral salts, when mixed with blood, oppose it's coagulation. This was previously shown by Hewson; but suspecting that this effect might be owing to the agitation which he recommends to give the mixture in order to favour the solution of the salts, about six ounces of

blood were received in two flasks, the one of which contained a solution of half an ounce of sulphat of soda, and the other, a solution of the same quantity of muriat of soda; and the effect was, that the mixtures preserved their fluidity, and there was no coagulum to be observed.

In order to find out if it was not the density of the fluid, rather than the action of the different saline matters, that prevented the approaching of the fibrous part, and consequently the formation of the coagulum; some blood was received in two vessels, one of which contained a solution of gum arabic, and the other a solution of starch, but the coagulation took place in both vessels, whether the liquids were hot or cold. Hence it appears, that this coagulation which the blood undergoes is independant of the action of air, heat, cold, or the density of the liquor.

The coagulum, or clot, preserves it's consistence and odour for three, four, or five days, especially when the vessel that contains it exposes but a small surface, and is placed in a fresh place; in a warm temperature, or the contrary, it soon becomes softer, suddenly loses it's consistence, it's colour begins to change, and at last it is extremely foetid.

If instead of letting the coagulum remain in the serum, it is separated from it, and placed in a warm situation, it becomes dry without suffering any change; in this case, it's colour is of a very deep red, and towards the edges it acquires a semitransparency. If the coagulum separated from the serum be left to drain for the space of half an hour, and be afterwards exposed to the heat of a water-bath, it becomes of a more solid consistence, and the liquor which drops from it is in all it's properties the same as the serum. If the coagulum be put into a certain quantity of boiling water, it gives this fluid a milky hue; there likewise arises at the same time to the surface a

The coagulum.

Exposed to heat.

scum, which is owing to a portion of dissolved albumen; the coagulum is then of a brown colour and more solid.

Alcohol.

If the coagulum be digested in spirit of wine it likewise increases in consistence; but the serum which separates contains no more albumen. On leaving the alcohol to remain on the clot, it only acquires a lemon colour, provided it has been perfectly dephlegmated, and its mixture with water does not change its transparency.

Water.

This is not the case with water; this fluid divides the coagulum, becomes red, and remains transparent for many days; but it insensibly becomes turbid, and there arise some *membranous pellicles*.

Acids.

Acids have more or less action upon the coagulum; they all, however, increase its solidity by coagulating the albumen which is still contained in the serum. To this the nitrous acid is an exception, for it appears to bring about its dissolution, whilst the phosphoric and sulphuric acids change it to a black. When the coagulum has been exposed to the action of the acids, it is no longer soluble in water as before, it is only divided by it, by which its transparency is affected.

Alkalis.

The carbonats of potash and ammonia dissolve the coagulum. When these alkalis are in their pure state (deprived of their carbonic acid) they give it a deep red colour. This species of solution may be preserved some time without becoming putrid or undergoing any change. There is no appearance of those *membranous pellicles*, above-mentioned, since it appears, that the alkali, on combining with them, has given them a species of solubility.

Distilled.

If the coagulum be distilled in a retort, it affords the same products as other animal substances, and the carbon which remains, contains iron, soda, &c.

On giving an account of the property which water has Fibrin. of dissolving the coagulum, it was observed, that there always remains behind a *membranous matter* on which this fluid has no action. This is easily separated by a very simple method; it is only necessary to enclose the coagulum in a piece of linen, and to rub it between the hands at different times, in a vessel filled with water, when the soluble part will separate by degrees and leave a residuum, which is the real fibrous matter of the blood, and which so many authors have confounded with the coagulable lymph. It is in large quantity. It is most probable that this fibrin exists in the coagulum of the blood in a state of extreme division, and that it only takes the form observed, on using the process already described; that is, by the motion imprinted on the coagulum by agitating it in water. This idea appears to be supported by what is observed on agitating the blood just drawn from the vein, when the fibrous matter separates in large quantity, and adheres to the hands or the instrument made use of to agitate this fluid.

The manner of extracting the fibrin, in the above experiment, appears to Parmentier and Deyeux to be of use in explaining the manner in which it separates spontaneously in the living body. According to the greater part of physiologists, this matter is destined for the purpose of forming and repairing the substance of the muscles; if this be the case, it may be supposed, that the blood, by being in a constant motion during it's circulation, tends by such agitation to deprive itself each moment of it's fibrous matter, and to deposit it in greater or less quantity, and more or less suddenly according as it's motion is more rapid; whether this be the case or not, it is certain, that the fibrin is found entire in the fleshy part of the body, and that when it is separated from it, it is not sensibly different from that

which the blood affords that has been agitated on coming from a vein.

Explanation
of the
coagulation.

It appears, that the influence of this fibrous matter on the formation of the coagulum, or coagulation of the blood, has not been sufficiently attended to by authors. These chemists, however, are of opinion, that the property of the blood to remain fluid, when this matter has been separated from it by agitation or motion, should naturally incline a person to an opinion that it contributed to bring about the concretion of the substance that constitutes the coagulum; and the cause that produces this phenomenon they attempt to explain in the following manner, and which appears to be taken from the explanation previously given of it by Hunter, or greatly resembling it. Whilst the blood remains fluid and homogeneous, it may be considered as being still endued with life or vital motion. The fibrous part it contains, and which is found diffused through its whole mass, enjoys a sort of irritability; but in proportion to the distance of time the blood which contains it has been drawn from the vessels, it loses its motion, in short, it happens at the instant the vital principle entirely leaves it, and it may be considered as in a state of death, that still preserving, during some seconds, the motion of the palpitation of the expiring flesh, it contracts, unites with a part of the matter near it, and retains and communicates to it this state of trembling jelly, the external properties of which have always imposed upon the cause of the real formation of it.

These chemists at first agreed with what several ancient and modern authors had supposed, that the coagulation of the blood out of the vessels was owing to the cessation of the natural heat; and they were willing to adopt this opinion from observing, that it is principally when this fluid is entirely cool, that the whole mass of

blood is in the form of a coagulum, and in certain respects to be compared with the jellies of fruits; but the reflection of Hewson, and further experience, particularly from their frequenting the butchers, changed their opinion, and afforded them no doubt but that the blood in it's separation and coagulation follows none of the laws attending on cold; but that repose and motion are the two great means of operating or preventing this decomposition.

Not affected
by cold.

But by re-
pose and
motion.

This is supported by the observations of Hewson, who, on examining the blood as it flowed at different times, found, that the blood which came immediately after the opening of the vein required more time to coagulate than that which he received later. The same was also verified by these chemists, who, on attending the butchers, observed, that the blood that first spouted from the vessels of a beast was very fluid, but in proportion as these vessels lose their spring, and the organic action weakens and life escapes, the blood acquires more consistence, and flows nearly coagulated or nearly dead when the animal expires: that whatever be the temperature, the coagulation takes place at the same time, if the motion and action of salts do not interfere immediately to destroy the vital irritability of the fibrous matter, and kill it; if this last be the case, the blood is only in the form of a liquid, which no means yet known can recal to a state of coagulation. In those animals whose blood contains a very large proportion of fibrous matter, it's concretion is made in a very regular and uniform manner; as is the case with the blood of the ox, the coagulum of which is only to be divided with nicety in certain directions, and always in the form of lamellæ.

If one or several of these be separated from a clot of this kind, all the saline matter may be separated from them by means of ablution in water, whilst the fibrous

matter, deprived of it's colour, remains alone, representing a mass of very delicate texture. Such are the ideas of these two chemists on the formation of the coagulum.

Their experiments were also repeated on the blood of many domestic animals, such as that of the horse, sheep, calf, lamb, and pig, and they found, that this fluid afforded the same products in all. It appeared, that only the state of these products presented any very sensible difference; for example, the blood of the calf and lamb always afforded a fibrous matter, the texture of which was soft when compared to the ox and sheep. The serum likewise produced an albuminous matter, which underwent no great degree of coagulation by heat. They found, in general, that the state of health, and vigour of animals, had peculiar influence on the albumen; for on examining the blood of diseased persons, it often happens, on comparing it with that of healthy individuals of the same species, that very marked differences were to be observed in this substance.

Albumen
greatly
affected by
health and
disease.

Colouring
matter.

The next object which these chemists had in view was the examination of the colouring matter. To obtain it, some fresh formed coagulum was put into a linen bag, and washed in distilled water until the fibrous matter was completely separated. On heating the water of ablution by the water bath, there soon arose a thick matter of a very deep red colour, which swam in the fluid that had previously held it dissolved; this being separated by the filter, and strongly expressed to deprive it of all it's humidity, had lost it's continuity, was easily crushed, and was reduced to a powder; in this state it had neither odour nor flavour, and being exposed to a gentle heat, it became of a very decided black colour.

Acids.

The diluted acids had no action upon it, but when concentrated they decomposed it, and reduced it to a spe-

cies of coal, and this is more effectually done by the assistance of heat.

Fixed and volatile alkalis have very little action on it; Alkalis, but the solution insensibly takes place when these alkalis are in a caustic state, and assisted by heat.

Spirit of wine, digested on this matter, was not sensibly coloured by it. Alcohol.

Vitriolic ether receives a yellow hue from this matter, but soon lets it fall down, and only preserves a slight yellowish colour, which soon leaves it.

The same effect takes place when this matter is boiled on a moment in fat oil.

On distilling the colouring matter in a retort, it affords products similar to those which the serum, fibrous matter, and the whole blood afford when submitted to the same process. Distilled.

From the above, it appears, that this matter, which has been coagulated by the heat, is only the albumen of the serum combined with the colouring part; and it may be readily conceived, that the albuminous matter ought to make part of it's composition, since it is in the midst of a fluid filled with albumen that the coagulum is formed, and that this being divided and left to drain, affords a serum similar in it's chemical properties to that separated on the formation of the coagulum. To prove this, however, it is necessary to isolate the albumen from the tinging substance that colours it red; but the experiments which these chemists made with this view were not so successful as was expected. Combined with the albumen.

The insufficiency of chemical means gave reason to suppose at first, that the redness of the blood was only produced at the instant of combination of the body which gave the colour (although not coloured itself) with the substance of the coagulum, in the same manner as oxygen when added to lead and mercury in mi-

nium and red precipitate. But this idea of the coloration of the blood was soon abandoned by the chemists; for, on consulting the opinions of different authors, they found that the opinion which attributed the cause to the iron this fluid contained had many partizans, especially since it has been proved, that iron introduced into the animal system in the form of medicine singularly exalted the colour of the blood, and even restored it's colour after it had lost it.

Iron in the
blood.

With respect to this metal existing in the blood, chemists have been more occupied in finding it than in determining with precision the state in which it exists; but it's demonstration in this fluid is complete, as appears more particularly from the experiments of Rouelle, Menghini, and Galeati, who limited themselves to one experiment, which proved that fire is absolutely unnecessary to detect it's presence, and that it is sufficient to mix a little powder of nut galls with the blood for it to become in less than 48 hours of a deep black colour. Besides, if the blood be exposed to a heat inferior to that of boiling water, the coagulum pressed and dried in the air gives unequivocal proof to the magnet of the existence of this metal.

It's colour
explained
by it.

A further examination of the chemical phenomena arising from this subject has given these chemists reason to think, that they have found the solution of the problem of the coloration of the blood, and they explain it in the following manner :

Since iron exists in the blood, it must be either in the state of a metal, an oxyd, or combined with an acid, and consequently in a saline state ; or lastly, combined with a body which, without being acid, is capable of forming with it an union, which gives it the property of being soluble in aqueous fluids : and it was upon these grounds that these chemists directed their researches.

Not in
metallic
state.

They found that iron exists in the blood neither in a

matellic state nor as an oxyd; for on diluting some blood with water and pressing the liquor through a filter, or keeping it in a fresh and tranquil place, they found no iron either on the filter or at the bottom of the vessel, which ought to have been the case from the weight of it's particles; and with respect to any martial salt being in the blood, the soda which exists in it would prevent it's formation.

It was on calling to mind the different properties of fixed alkali, and especially that of being able to dissolve iron under certain circumstances, that these chemists think they have discovered it to be the real solvent of iron in the blood, and that the solution of this metal thus effected is the colouring principle of this fluid. In order to explain the solution of iron such as it is found in the blood, they show the manner by which a similar solution is effected out of it. If a very small portion of iron at a time be put into some diluted nitric acid, a solution takes place, and when it is perfectly saturated fixed alkali may be mixed with it in excess, which immediately communicates to the liquor a very deep blood colour. In this case the nitric acid in dissolving the iron is in great part decomposed; the metal unites to the oxygen, one of the principles of the acid; and it is only after it is well saturated with this, that the portion of acid undecomposed lays hold of and dissolves it. The alkali being added takes the oxyd of iron from this acid, and instead of precipitating combines with it, and it is precisely at the moment this combination takes place that the red colour appears.

But dissolved by the soda.

Which produces the colour.

The liquor therefore contains two different combinations, the one is nitre, and the other a composition formed from the union of the fixed alkali with the oxyd of iron, which combination of alkali with the iron gives it solubility. These chemists suppose that a similar combination takes place in the blood, but in order to effect it

nature has no need of employing the nitric acid as an intermedium; any other acid is sufficient to have dissolved the iron, such as the phosphoric, which many chemists have proved to exist in the blood; or even without admitting a previous solution of the metal in an acid, it is sufficient that the iron in the blood be properly oxygenated in order that the fixed alkali may be capable of combining with it, and the oxydation of the iron may be conceived, on recollecting the large quantity of oxygen which is introduced into the lungs by means of respiration.

As to the quantity of iron in the blood it cannot be doubted, admitting it's solution by the fixed alkali, that there is a sufficiency of it to produce a liquor of a very beautiful red colour. As a proof, however, two scruples of iron, the quantity supposed to have been found in one pound of blood, were dissolved with some fixed alkali, and the solution obtained was of a beautiful red, and sufficiently deep to colour more than one pound of water. The mass of blood contained in the human body has been valued in different ways, but as it appears from the calculations of many physiologists that a middle aged healthy person requires 25 pounds of blood for existence, it follows from the experiments of Menghini that in such proportion there must be 70 scruples, or 2 oz. 7 drachms 1 scruple of iron. This quantity is certainly very considerable, and Menghini is of opinion that some future age may see nails, swords and other instruments manufactured from the iron contained in the human blood. If therefore it be added to what is already mentioned, that fixed alkalies and nitre mixed with the blood increase it's colour and render it more durable, and that the same effect takes place from the solution of iron by fixed alkali in the above experiments, it would appear that the opinion of these chemists on the solution of iron in the blood

by fixed alkali, as well as the coloration of this fluid by this same solution, cannot be looked upon as entirely devoid of probability.

Whatever, however, may be the opinion adopted on the colour of the blood, it is certain that the coagulum is a composed body, and that the red colour has no influence on it's formation, whilst the oxygen acts a great part in this coloration, for when it is in contact with the blood, the red colour always sensibly increases.

It is undoubtedly to the change the blood undergoes by the action of heat, which contracts it on drying, that the disappearance of it's red colour and it's becoming of a deep black, are owing. The iron deprived of the alkali that held it in solution, and a part of the oxygen which constitutes it an oxyd, changes it's state, hence, when separated by the magnet it is of a different colour to what it was when in a state of solution.

Since the explanation of the red colour of blood given by these two chemists, Dr. Wells, in an ingenious memoir in the Philosophical Transactions, has made some experiments and observations on the same subject. He is of opinion that there is no proof of blood deriving it's colour from iron, and that no other argument has been given in support of it, than that the red matter is found to contain that metal. He asserts that there is no necessary connection between redness and iron, since the same metal exists in many bodies of other colours, and even in various parts of animals without colour, as bones and wool, and he gives the following more direct reasons for rejecting the opinion of this metal being the cause of the red colour.

Dr. Wells
of a con-
trary opi-
nion.

1st. There is no colour arising from a metal, that can be permanently destroyed by exposing it's subject, in a close vessel, to a heat less than that of boiling water. But this happens with respect to the colour of blood.

His reasons.

2d. If the colour from a metal in any substance be destroyed by an alkali, it may be restored by the immediate addition of an acid; and the like will happen from the addition of a proper quantity of alkali, if the colour has been destroyed by an acid. The colour of blood, on the contrary, when once destroyed, either by an acid or an alkali, can never be brought back.

3d. If iron be the cause of the red colour of blood, it must exist there in a saline state, since the red matter is soluble in water. The substances, therefore, which detect almost the smallest quantity of iron in such a state, ought likewise to demonstrate it's presence in blood; but upon adding Prussian alkali and an infusion of galls to a very saturate solution of the red matter, the slightest blue precipitate could not be observed in the former case, or that the mixture had acquired the least blue or purple tint, in the latter case.

The change of colour by air and neutral salts not produced on it's colouring matter.

Dr. Wells likewise made some experiments to show that the alteration produced upon the colour of blood, both by common air and the neutral salts, is independant of any change effected by them upon it's colouring matter; in making these experiments he found the following precautions necessary.

Precautions necessary in making the experiments

1st. That the blood should be newly drawn and the weather cool. For as the solution of the red matter is not to be filtered, but must become transparent by the gradual subsiding of whatever may render it turbid, if the blood be old, or the weather warm, it will often assume before it be clear a dark and purplish hue. When exposed in this state to the atmosphere in a broad and shallow vessel, it's colour changes to a bright red, which however is not brighter than the proper colour of the solution. The dark purplish hue seems owing to some modification of sulphur, for the solution possessing it smells like hepatic air, particularly when agitated, and tarnishes

silver which is held over it. Neutral salts produce no change upon this colour.

2d. The neutral salts should not be added to the red solution, except when perfectly transparent, otherwise the salts will render it more turbid, and the mixture will appear brighter, if seen by reflected light.

3d. Lastly, the red solution ought to be poured gently from the vessel in which it has been made, otherwise, as it is a mucilaginous liquor, it is apt to entangle small particles of air, which by acting as opaque matter, will for some time alter the appearance of the solution. With these precautions he began his experiments; he infused a piece of black crassamentum of blood in distilled water, and immediately covered the vessel closely to prevent any excess of air. Having thus obtained a transparent solution of the red matter nearly free from serum and coagulable lymph, he exposed a quantity of it to the open air, in a shallow vessel, and poured an equal quantity into a small phial, which was then well closed. After several hours the first portion was decanted into a vessel of the same size and shape as that of the second, and having added to it as much distilled water as compensated its loss by evaporation, the two were compared together, and were found exactly of the same colour. Two other equal quantities of the red solution were afterwards poured into two phials of the same size and shape; to one, a little of a solution of nitre in water was added, and to the other, as much distilled water. On composing these together their colour was also precisely the same. Lastly, he cut a quantity of dark crassamentum into thin slices, and exposed them to common air, and when they became fluid, put them into a phial containing distilled water. He then took as much of the same crassamentum, which was still black, and infused it in an equal quantity of distilled water, contained in a phial similar to the former. The two

solutions thus obtained, one from fluid, the other from black blood, were however, of precisely the same colour. The same results were the consequence of repeated experiments.

Explained
on the theory
of Kepler,
&c.

Assuming, therefore, as proved, that neither common air nor the neutral salts (all those which were tried being similar to nitre in this respect) change the colour of the red matter of blood, Dr. Wells attempts to explain the manner in which those substances give, notwithstanding, to black blood a fluid appearance; which is founded on the theory of Kepler, Zucchius, and Delaval, viz. that the colours of opaque bodies do not arise from the rays of light which they reflect from their anterior surfaces, but from that portion of it, which having penetrated their anterior surfaces is reflected by the opaque particles which are diffused through their substance.

In adapting this theory to the explanation, Dr. Wells first supposes, that all the parts of blood have the same reflective power. The consequence of which will be, that a mass sufficiently thick to suffocate the whole of the light which enters it, before it can proceed to the posterior surface, and be thence returned through the first surface, must appear black; for the rays which are reflected from the first surface are without colour, and by hypothesis, none can be reflected from it's internal parts. In the next place, let there be dispersed through this black mass a small number of particles, differing from it in reflective power, and it will immediately appear slightly coloured; for some of the rays, which have penetrated it's surface, will be reflected by those particles, and will come to the eye obscurely tinged with the colour, which is exhibited by a thin layer of blood, when placed between the eye and the light. Increase now by degrees the number of those particles, and in the same proportion as

they are multiplied, must the colour of the mass become both stronger and brighter.

Having thus shown that a black mass may become highly coloured, merely by a considerable reflection of light from its internal parts, he thinks, that if he should be able to prove that both common air and the neutral salts increase the reflection of light from the internal parts of blood, at the same time that they brighten it, great progress would be made in establishing the opinion, that the change of its appearance occasioned by them depends upon that circumstance alone, and the following observations he thinks place this point beyond doubt.

On comparing several pieces of crassamentum, which had been reddened by means of common air and the neutral salts, with other pieces of the same crassamentum, that were still black or nearly so, he found that the reddened pieces manifestly reflected more light than the black. One proof of this was, that the minute parts of the former could be much more distinctly seen than those of the latter. Now this increased reflection of light in the reddened pieces could not arise from any change in the reflective power of their surfaces, for bodies reflect light from their surfaces in proportion to their density and inflammability, and neither of those qualities, in the reddened pieces, can be supposed to have been augmented by common air or a solution of a neutral salt in water. The increased reflection must, consequently, have arisen from some change in their internal parts, by means of which much of the light which had formerly been suffocated, was now sent back through their anterior surfaces, tinged with the colour of the medium through which it had passed.

The precise nature of the change of blood by neutral salts, Dr Wells thinks is manifest by the following experiment. He poured upon a piece of printed card as

much serum, rendered very turbid with red globules, as barely allowed the words to be legible through it. He then dropped upon the card a little of the aqueous solution of nitre, and observed, that wherever the solution came in contact with the turbid serum, a whitish cloud was immediately formed. On stirring the two fluids together, the mixture became so opaque that the printed letters could no longer be seen. He has not been able hitherto to devise any experiment, which shows the exact change induced by common air, but thinks it is evident, that air must also increase in some way the opacity of blood, since it cannot by any other means increase the reflection of light from the interior parts of that body.

The same theory explains other facts.

This theory explains another fact respecting the colour of blood, which might otherwise seem unaccountable. If a small quantity of a concentrated mineral acid be applied to a piece of dark crassamentum, the parts touched by it will for an instant appear florid; but the same acids added to a solution of the red matter in water do nothing more than destroy it's colour. On examining the crassamentum, the cause of this difference of effect is discovered, for the spots upon which the acid was dropped are found covered with whitish films. Hence it is evident to Dr. Wells that the acid had occasioned an increase of opacity in the crassamentum, more quickly than it had destroyed it's colour; and that the red matter, from having been in consequence seen by a greater quantity of light, had in that short interval appeared more fluid than formerly.

Conversion of cinnabar into vermilion.

The change which takes place in blood, when it's colour is brightened by common air and the neutral salts, is similar to that which occurs to cinnabar, in the making of vermilion. This is made by subjecting the cinnabar to a minute mechanical division. But the effect of this division is to interpose among it's particles an infi-

finite number of molecules of air, which acting as opaque matter, increase the reflection of light from the interior parts of the heap, and occasion all the difference of appearance between these two states of the same body.

It may be said in opposition, that granting an increased reflection of light from the interior parts of the blood, in consequence of air and neutral salts, still this is not a sufficient cause for the production of the colour; for after their action it is a scarlet, which according to Dr. For-
Objection answered.
 dyce differs not only in brightness, but also in kind from the ordinary colour of blood, which is a modena red. The answer is, that there are examples, besides that to which the objection is made, of dark blood appearing florid, merely from it's colouring matter being seen by means of an increased quantity of light. Thus by rubbing a piece of the darkest crassamentum with a proper quantity of serum, the mixture in a few seconds takes a colour similar to that given by common air. But nothing is done but interposing among the red globules a number of the less dense particles of serum, which acting as opaque matter increase the internal reflections. Likewise, on viewing by transmitted light the fine edges and angles of a piece of crassamentum in water, their colour appears to be a bright scarlet, though all the other parts of the same mass are black. These facts appear to this chemist to be sufficient to prove what has been already advanced; but he goes a step further, and shows how the modena red is converted into a scarlet.

Blood he found by experiment to be one of those fluids, which Sir Isaac Newton observed to appear yellow when
Appearance of colour.
 viewed in very thin masses: when therefore a number of opaque particles are formed in it by the action of common air and neutral salts, many of them must be situate immediately beneath the surface. The light reflected by these will consequently be yellow, and the whole effect of

the newly-formed opaque particles, upon the appearance of the mass, will be the same as if yellow had been added to it's former colour, a modena red. But modena red and yellow are the colours which compose scarlet.

Origin of
the colour.

Upon the whole it appears to Dr. Wells, that blood derives it's colour from the peculiar organization of the animal matter of one of it's parts; for whenever this is destroyed, the colour disappears, and can never be made to return, which would not be the case if it depended upon the presence of any foreign substance whatever.

Miscellaneous
observations.

He concludes with several miscellaneous facts respecting the colour of the blood, and some consequences that may be derived from them.

Substances
that transmit
air to
blood.

It had been mentioned by Dr. Priestley, that the only animal fluid beside serum, which he found to transmit the influence of common air to blood, was milk. Dr. Wells has observed that the white of egg, or a solution of sugar in water conveys the influence of air to blood, from which it seems probable that milk owes it's similar property to the saccharine matter it contains. Mucilage of gum arabic had no such effect.

Neither serum
nor solutions
of neutral salts
extract colour
from blood though
they dissolve
the red part.

He found (contrary to what had been asserted before) that saturated solutions of all the neutral salts extract, though slowly, red tinctures from blood, some of which are very deep, and neither they nor serum, added in any proportion to a solution of the red matter in water, alter it's colour or transparency, except by diluting it. For having added a drachm of distilled water to an ounce of serum, the mixture was poured upon a small piece of crassamentum: and upon an equal piece of this last a drachm of water was poured, and an ounce of serum after some time was added. Each parcel therefore contained the same quantity of crassamentum, serum and water, but the crassamentum upon which the mixture of serum and water had been poured communicated no tinge to it, while the

other piece, to which water had been first applied, and afterwards serum, gave a deep colour to the fluid above it. Similar experiments were made with crassamentum, water, and a dilute solution of a neutral salt, which were attended with the same results.

Since then neither serum, nor a dilute solution of a neutral salt, will extract colour from blood, though they are both capable of dissolving the red matter, when separated by water from the other parts of the mass, it follows, according to this chemist, that the red globules consist of two parts, one within the other, and that the outer, being insoluble in serum or dilute solutions of neutral salts, defends the inner from the action of these fluids. The microscopical observations of Hewson led to the same conclusion, that the red globules consist of two parts, an exterior vesicle and an interior solid sphere. The exterior part of the globule appears to Dr. Wells to be that ingredient of the blood upon which common air and the neutral salts produce their immediate effect, when they render the whole mass fluid, for they neither act on the red matter, nor do they occasion any change in the coagulated lymph or serum. It seems evident also that there exists an animal matter in the blood, different from the coagulable lymph, the coagulable part of the serum, the putrescent mucilage and the red particles.

Dr. Wells is of opinion, that although all reasoning founded upon microscopical experiments ought perhaps to be regarded as in great measure conjectural, yet those of Hewson appear likewise to furnish a reason, why both water and a saturate solution of a neutral salt can extract colour from the red globules, though a mixture of those fluids be incapable of the same effect. For water applied to the red globules separates the exterior vesicles from the red particles, which are now open to the action of any solvent. The addition however of a small quantity of a

Hewson's
observations
on the red
globules
confirmed.

Afford other
explanations
respecting
the red glo-
bules.

Extended
further by
Dr. Wells,

neutral salt to the water enables the vesicles to preserve their shape and retain the inner sp̄nericles. On the addition of a larger quantity of salt the vesicles contract, and apply themselves closely to the red particles within. Thus far Hewson. Let it now be supposed that the vesicles contract still more, from a further addition of salt to the water; then, as the internal particles are incompressible, the sides of the vesicles will be rent, and their contents exposed to the action of the surrounding fluid. Both water, and a strong solution of a neutral salt, may therefore, according to Dr. Wells, destroy the organization of the vesicles, though in different ways, and thus agree in bringing the red matter in contact with a solvent, while a mixture of those two fluids, viz. a dilute solution of a neutral salt, will, by hardening the vesicles, increase the defence of the red matter against the action of solvents.

Heme.

From the experiments of Charles Grover instituted by Home, it appears the blood is capable of uniting with a quantity of urine equal to itself, so as to form a firm coagulum; that the red particles do not dissolve in this coagulum, but it is dissolved by the surrounding urine; that an admixture of urine prevents the blood from becoming putrid, and the coagulable lymph breaks down into parts nearly resembling a soft powder. He was led to make these experiments from a circumstance that happened to a patient. He had a rupture of a vessel in one of the kidneys, and from the symptoms, it seems, that part of the blood which passed into the bladder from the kidney remained there and formed a coagulum, which coagulum gave a bloody tinge to the urine, and caused an inability to void it without assistance, till it was dissolved by the urine. Experiments out of the body perfectly agreed with what happened in the bladder.

The last experiments on healthy blood were made to discover the quantity of carbon in it, which was found

to exist in larger proportion in the arterial than in venous blood. 1. Abildgaard, on drying 100 parts of the venous blood of a horse, by a moderate heat got 26 parts of a substance sufficiently dry for pulverization, whilst the same quantity of arterial blood afforded 25. 2. To alkalize, after Kirwan's method, 1 oz. of nitre by detonation (480 grains to the oz.) required 192 grains of venous, and only 160 of arterial blood. 3. An oz. of venous blood, after being dried and decomposed in a close vessel, afforded $115\frac{1}{2}$ grains of carbon, whilst the same quantity of arterial blood only gave $87\frac{1}{2}$ of carbon. 4. To decompose 480 grains of nitre, 148 grains of carbon of venous blood were necessary, but only 119 grains of that of arterial blood: this experiment, however, Abildgaard looked upon as not very exact, from a part of the carbon flying off like a dust. The carbon of arterial was likewise much lighter than that of venous blood. 5. Having separated the red part of the blood from the serum and fibrous part, it was dried and tried with nitre, and he found that 130 grains of this red part were necessary to alkalize 480 grains of nitre, whilst it required 202 grains of fibrous part separated from the serum, and well washed, to alkalize the same; this part however detonated with more vivacity than the other parts of the blood. Such are the experiments and observations that have been made on the nature and properties of blood in it's healthy state.

Before the experiments of Parmentier and Deycux, little or no attempt had been made to determine by analysis the change that blood undergoes when affected by disease. The investigation of these chemists was confined to the human blood, and the standard, by which a comparison of the products was made, was taken from healthy people of both sexes, of good constitutions, and of different ages and temperaments. They found the blood of a

Diseased
blood.

young person, in general, to have a more lively red colour than that of a middle aged person; that the albumen of the serum does not acquire so much firmness; that the coagulum has less consistence, and that the fibrous matter is not so abundant: as to the other products, they were similar to those which the blood of other animals afford; to which it may be added, that no notice was taken of the quantity of the products of different subjects, but only of the constituent parts, the comparative quantities varying more or less every day in the same subject.

In an inflamed state.

The blood of persons affected with inflammatory diseases was first examined. Some was taken from a young man twenty-six years old, of a strong and vigorous habit: he had been suddenly seized with a pain in his side, accompanied with fever, oppression, and a spitting of blood.

This blood, on coming from the vein, was of a beautiful red colour, the coagulum was very soon formed, the serum separated from it, and the surface of the coagulum was covered with a whitish solid *buff*, of the thickness of a crown piece, which when it had acquired all its firmness, was separated from the coagulum. The coagulated part was less consistent than that of healthy blood; it very much resembled red currant jelly, not sufficiently boiled. Water readily dissolved it, and at the same time some fibrous particles or pellicles, extremely thin and light, were observed to remain at the bottom of the vessel, but which soon arose on the least agitation. A part of the coagulum was put into a linen bag, and compressed at different times in water, by which means the fibrous part was left behind undissolved in the bag; it was in filaments, the same as in healthy blood when exposed to the same process. On exposing the water of the lotions to a boiling heat, a thick red coloured matter was separated, the physical properties of which did not appear

to differ from those of the same matter from healthy blood, and it afforded the same products.

The *buff* (*crusta inflammatoria*) which covered the *Buff*. surface of the coagulum, being washed in distilled water, became perfectly white, and preserved it's consistence and thickness; after having been wiped with blotting paper, it was supple and elastic, and formed an homogenous semitransparent substance, without presenting any fibrous texture or tearing; it resembled a piece of white skin that had remained some time in water.

It's specific gravity was less than that of water. Sp. gr.

It was not affected by cold water, but on being digested Water. in boiling water it resembled flesh in it's being acted upon, and it became hard.

Very diluted acids had scarcely any effect upon it, but Acids. vegetable acids, particularly vinegar, completely dissolved it, and these solutions were decomposed by fixed alkalis.

Fixed and volatile alkalis; in their mild state, had very Alkalis. little or no action upon it, but in their caustic state and by digestion, they dissolved it.

It's exsiccation is soon effected by placing it upon the Exsiccation. large mouth of a bottle, thus diminishing it's points of contact: in this situation, it loses all it's humidity in the space of twenty-four hours, and is reduced to a very thin semitransparent substance, resembling a piece of bladder. Before and after it's exsiccation, it affords the same products as the fibrous matter.

Exposed to a humid air, it soon becomes putrid: it Putrefac- loses it's consistence by degrees, and is converted into a tion. kind of puriform matter of so disgusting an odour as to be difficult to support.

The *serum*, which, as before mentioned, separates at Serum. the same time with the coagulum, was of a transparent lemon colour; from it's flavour it appeared to contain

fixed alkali, which was corroborated by it's changing the syrup of violets green.

Heat. Boiling water being poured upon it, no coagulation of the albumen took place, but the mixture became of a milky colour, and resembled a solution of soap in water. Exposed to the heat of a water bath (baln. Mar.) it lost it's fluidity, and was converted into a white matter as thick as the hardened white of an egg, however, without entirely it's consistence and continuity, as there appeared to be a small quantity of fluid between it's particles which opposed their union. This matter contained sulphur.

Alkalis. Caustic fixed alkali with this serum formed a mixture that was no longer coagulable by heat; it remained constantly fluid, but on adding some distilled vinegar to it, the liquor became turbid, and a flaky substance separated which swam on it's surface; at the same time, a very sensible odour of sulphurous hydrogenous gas was disengaged.

Acids. Acids likewise do not trouble the transparency of this serum in a diluted state, but they coagulate it when concentrated; this effect is more particularly produced by the sulphuric acid.

Alcohol. This fluid is also acted upon by spirit of wine, for they scarcely come into contact when the mixture becomes turbid and milky.

Distillation. Lastly, if this serum be distilled on the open fire, there are obtained phlegm, oil, fluid, and concrete ammonia; and a light and then a thick heavy oil. Towards the end of the process, the matter tumefies, and at last, a light coal is found at the bottom of the retort, from which iron was extracted by the magnet; afterwards soda and muriat of soda were obtained by lixiviation and spontaneous evaporation.

Compared with healthy blood. Amongst the different products which the analysis of this inflammatory blood afforded, there are some, that

presented characters not to be found in ordinary blood, such are

1st. The buffy matter.

2d. The soft state of the coagulum the surface of which was covered by the buff.

3d. The want of continuity of the albumen separated from the serum by means of heat.

4th. The impossibility of producing the concretion of the albumen by pouring boiling water on the serum.

5th. The milky colour which the mixture receives.

Amongst all the products, the buffy part is one of those which appears principally to have fixed the attention of authors who have written on the blood. Having been taught by observation, that it only existed under certain circumstances, it's presence was looked upon as indicating some disease, but they agreed very little respecting either it's nature, composition, properties, or origin.

Thus Sydenham attributed it's origin to the lymphatic and fibrous part of the blood. Malpighi and Haller looked upon it as formed by the thickening of the chylous and nutritive matter of the blood. Quésnoy and Sauvages had no doubt of it's being perfectly formed pus, or nearly so; and Gabert, who had at first adopted the same opinion, afterwards abandoned it, and believed it to be one of the albuminous products which separates from the serum.

Hewson, Moscati, and Callison believed, that it arises from the crassamentum. They explain it's formation by saying, that the blood, and particularly the coagulable part, is more dissolved and diluted than other blood, on which account the more specifically heavy red part has time to separate and fall to the bottom, whilst the lighter colourless part remains at the top; and they conclude, that the action of a real inflammation consists in a lessened coagulability of the blood. Borden and Robert regard it as the product of a sort of mucilage

Nature of
the buff.

Various opi-
nions of it.

with which the blood abounds. Hey, Lappenberg, and Burfenius, impute it to an increased coagulability of the blood, which is partly occasioned by an internal change of it's previous mixture, and a proportionable increase of the fibrous part to the serum, and partly to the increase of the coagulable part of the serum. Gren likewise attributes it to the increased coagulability, and the increase of the fibrous part of the blood. According, however, to de Haen, Siveton, and Boerhaave, the buff is not always present in a true inflammation, and it exists sometimes when this inflammation is not present; and Burferius found it in the blood of horses in their most perfect health. Such are the diversity of opinions respecting this substance, but the perfect analogy which the above experiments show there is between it and the fibrous matter leaves no doubt on it's nature. It still remained to discover the manner in which the separation of the buff takes place, which was done in the following manner:—

Separation
of the buff.

Some blood, in which a buff was expected to form, was received in a porcelain vessel, and every thing about to take place was examined with minute attention. It was observed, that in proportion as the blood approached towards coagulation, the first lineaments of the buff began to be formed upon it's surface. By means of a needle some of this buff was separated; it appeared in the form of filaments, more or less long, their consistence and elasticity resembling those of the fibrous filaments. It was at first thought possible that the same separation might be continued as the buff appeared, but the coagulation suddenly taking place, it's surface was covered with a pellicle, which soon became thick and put an end to the experiment; otherwise, the coagulum might have possibly been procured deprived of it's buff, which would have led to the theory of the formation of that substance.

Admitting therefore, that the buff owes it's origin to the fibrous matter; which cannot be doubted, from it's possessing all the properties of that matter; it appears probable to Parmentier and Deyeux, that it's formation can only take place, because the particles of the fibrous matter dissolved in the blood, so long as they are endued with vital motion, lose their solubility in proportion as the blood coagulates; afterwards from their specific gravity they rise to the surface, where by uniting, they give rise to the solid body called buff. What appears to justify this explanation, is the facility with which the formation of this substance is prevented, for by separating the fibrous matter by means of agitation, the particles of it not being then able to collect spontaneously together, must necessarily appear under another form; so that, instead of a homogenous substance possessing continuity and a sort of texture, only oblong and elastic filaments are obtained, which are similar in every respect to the fibrous matter. The natural density of the blood that furnishes the buff undoubtedly facilitates the separation of the fibrous matter, and places it in a favourable state that it may collect itself; for when this density is diminished by diluting the blood with water, no buff appears; or if it be formed, it has not the same consistence as that which arises upon the blood when left to itself.

For the formation therefore of this buff, it is necessary that the blood have a certain degree of fluidity, above and under which the fibrous matter is not able to separate itself; but since this fluidity naturally diminishes in proportion as the blood loses it's vital principle, it is not extraordinary, that a certain quantity of fibrous matter should always remain confounded with the substance of the coagulum, which may be obtained by washing the coagulum in water.

The separation of the fibrous matter employed in form-

Opinion of
Parmentier
and Deyeux.

ing the buff, may likewise be regarded as the cause of the softness which, as above mentioned, is natural to the substance of the coagulum. Indeed, if, as has been already shown, the coagulum only owes it's consistence to the presence of a certain quantity of fibrous matter, the more inconsiderable the quantity of this matter is, the less will be the consistence of the coagulum; hence it ought to be infinitely more soluble in water than that which is deprived of all it's fibrous matter. In short, it would appear, that the fibrous matter, in order to enjoy the property it has of separating to form the buff, has undergone some alteration from the action of the disease; which, although insensible to the chemist, is not so by it's effects in the animal economy during circulation.

Lastly, the fibrous matter is not the only constituent part of the blood on which the disease appears to have acted; it's effects may be likewise remarked in a very sensible manner on the albumen; for it has been before observed, that it was coagulated with great difficulty by heat, and that once separated, it had never that consistence and continuity which it has when separated from the serum of healthy blood by the same means.

Before concluding this article on inflammatory blood, it may be observed, that on examining the blood of many patients, affected with inflammatory diseases, very sensible differences in the results are often to be observed. Sometimes the buffy part is very thick, at other times very thin; sometimes the serum is in large quantity, at other times in small quantity, and separated from the coagulum with great difficulty; likewise, the blood of different diseased people has different shades of colour. From these observations, the two chemists have acquired the most complete proof of the difficulty, or rather impossibility of finding any two bloods perfectly similar;

which is easily conceived on reflecting upon the diversity of accidents which, independent of the temperaments of each individual, always accompany inflammatory diseases, and which have a more or less marked influence not only on this fluid, but even on the other fluids of the animal system.

The next object of these chemists, was the investigation of the blood of persons affected with the scurvy; for this purpose they examined three patients who had the characteristic symptoms of this disease. Two of these were between twenty-nine and thirty years old, the third was forty-seven. The first was affected with pains in his side, independently of the symptoms of the disease, for which venesection was ordered: the second, and more particularly the third, had a general plethora, and the expectation of hemorrhage necessitated the act of V. S.

Blood of
scurbutic
persons.

First patient. This blood had a red colour with little brightness; the coagulum took place very readily, the serum was slightly lemon-coloured and transparent, and the quantity not greater than that of inflammatory blood. It's taste was alkaline; it changed the syrup of violets green, mixed with acids without effervescence, and without losing it's transparency; but it was coagulated by concentrated acids, alcohol, ether, and all dephlegmated spirituous liquors, which also produced a whitish matter in it that suddenly fell to the bottom of the vessel; alkalis increased it's fluidity. Exposed to the heat of boiling water, the serum coagulated, but not so firmly as in a healthy state; and when this coagulated serum was slightly pressed, a limpid and colourless liquor was obtained, which did not change the syrup of violets. The matter remaining upon the linen had all the properties of the albumen of the blood.

The coagulum of the blood, a short time after it's

formation, lost a part of its volume, but at the same time a small quantity of serum ran from it. Its surface did not present that lively and bright red froth which is observed in healthy blood, but it was covered with so thin a pellicle as not to prevent the substance of the coagulum from being distinguished underneath; the tenacity of this pellicle prevented its being separated. The consistence of the coagulum was the same as in ordinary blood, and the fibrous matter separated by means of water, was in as great a quantity, and as firm and elastic.

Second patient. The separation took place in this blood as in the preceding; the pellicle that covered it was whitish and somewhat thick; its consistence, however, was not very strong, as the least pressure was sufficient to tear it. The small portions taken after the ablutions, were white and semitransparent, and resembled those obtained from the long agitation of a piece of coagulum in cold water: on red-hot coals they were destroyed, giving an odour of burnt coal; they were dissolved by vinegar and caustic alkalis; but alcohol, on the contrary, made them solid.

The serum had nothing in particular.

Third patient. This blood was decidedly buffy, but the buff was not so thick as that of inflammatory blood, yet more firm than that of the second patient: it was easily washed in water without tearing; by washing it became very thin, but preserved its transparency; boiling water, vegetable acids, alkalis and alcohol had the same effect upon it as on common buff; on exsiccation it was reduced to so friable a leaf as to be divided into several parts on the least touch. The substance of the coagulum under this buff had a species of softness which permitted the water to dissolve it very easily, whilst at the same time, some membranous pellicles separated from

it, and fell to the bottom of the vessel. This coagulum inclosed in a linen bag, and washed with water, afforded, after solution, some very elastic fibrous filament.

The serum, and the red part, coagulated, appeared the same as those of the blood of the two first patients.

On taking a general view of the blood of the three patients, it was observed, that none of them had that peculiar odour which is so marked in healthy blood. This difference in the odorous principle, and a more or less disproportion to form buff, are the only essential differences to be observed in these three scorbutic patients. These chemists found the description of authors, who say, that the blood of scorbutic persons is more fluid than ordinary, not to be true, for it has very nearly the very same properties as healthy blood; it affords a coagulum of much consistence, and the quantity of serum is not more considerable. They observed, that if the serum was greater in quantity from one bleeding, the remainder was less voluminous, and *vice versa*; the consistence of that which afforded the least serum, less firm, whilst on dividing it a quantity of serum flows out that had been detained between its parts; that the more serum it affords, the less runs from it afterwards; and therefore, if the quantity of serum of one bleeding be compared with that of another, from the spontaneous separation and division of the coagulum, very little difference will be perceived; from which it would appear that all indications drawn from the apparent quantity of serum of the blood, are often erroneous.

Observations.

The greater or less opening in the vein, the greater or less considerable quickness with which the blood flows from it, the more or less marked weakness of the patient, the form of the vessel in which the blood is received, and the motion and agitation which it is scarcely impossible to avoid, may be considered as the principal

causes which hasten or retard the formation of the coagulum, and of it's sometimes retaining a large quantity of serum; whilst, at other times, it lets a greater or less quantity escape. It is not however to be supposed, that in all circumstances the blood of diseased people is equally serous; at the same time, it is an error in those physiologists who have advanced, that the fluidity of the blood of scorbutic people was more decidedly marked than that of the blood obtained in other diseases.

One reason of their having attributed this more than ordinary fluidity to scorbutic blood, appears to have been the facility with which it escapes from the vessels in that disease, and which Parmentier and Deyeux attribute to the debility of the vessels; which not being able to resist the least efforts, are easily torn and let the fluid they contain escape; hence, the hemiorrhages from the gums and nose of scorbutic people. The same happens in old people who are bled; their blood flows slowly, which is attributed to the same cause, the debility and flaccidity of the vascular system; and in many cases, old people finish their career by diseases that are very analogous to the scurvy. To the same causes, *viz.* the vessels being torn, and an extravasation taking place under the segments, these chemists think, those blue spots originate that are to be seen upon the legs of scorbutic patients.

Blood of
persons
under putrid
diseases.

The last diseased blood which Parmentier and Deyeux examined, was that taken from patients affected with putrid fevers. From their experiments it appears, that the blood of these patients was never alike. Sometimes the first bleeding afforded a very buffy blood; at other times the buff was very inconsiderable in quantity, and sometimes it was not present; it was likewise to be remarked, that the serum easily separated from the coagulum, although the separation was oftener more difficult.

The products by analysis presented nothing extraordinary; the buff appeared similar to that in inflammatory diseases; likewise, the substance of the coagulum beneath it had very little consistence, and was very soluble in water, which solution was coagulated by the action of heat, alcohol, and concentrated acids; whilst, on the contrary, fixed and volatile alkalis opposed it's coagulation, and singularly exalted its colour.

It was expected, on submitting it to distillation on the water-bath, that if the principle of putridity really did exist in the blood, proofs of it would be found in the products, such as volatile alkali, which is always obtained from substances in which putridity has taken place; but instead of this, a clear colourless fluid only was obtained, having the odour and light flavour of blood, and which had no effect on the syrup of violets. It was also observed, that diseased and healthy blood exposed to the same temperature, was nearly the same time in becoming putrid; from which it is concluded, that in putrid diseases, the principle of putridity does not exist in the blood.

On taking a general survey of the experiments, and recapitulating the observations and conclusions of Parmentier and Deyeux, on the nature and analysis of blood, it consists therefore of nine principal parts, *viz.* the odorous part, or aroma. Fibrous matter. Gelatin. Albumen. Red part. Iron. Sulphur. Alkali or soda; and water. The proportion of these parts vary almost infinitely, according to the age, temperament, and the manner of living; all of them having characters that essentially belong to them, with particular shades, which are often difficult to lay hold of.

1st. Odorous part. In the healthy subject, this part General recapitulation. Aroma. is very sensible, especially when the blood is fresh; by degrees it becomes weaker, in proportion to the change

the blood undergoes, and it entirely disappears when putridity takes place. In the blood of the diseased subject, the aroma is less decidedly marked; it is even probable, that in certain cases it is wanting. It appears that its affinity for the serum is less than that which it has for the coagulum; for this last substance preserves it entirely for some time; whilst the serum, when perfectly separated, is devoid of it. It seems to have a very sensible analogy with the aroma of vegetables, since both of them, independent of their action upon the organs of smell, are soluble in water, in air, and in spirituous liquors.

Fibrin.

2. Fibrous matter. This matter appears to exist in the blood, if not in a state of solution, at least in a state of extreme division. To bring about the separation, a rapid motion of this fluid is sufficient; or it may be obtained by diluting it with a certain quantity of water. In the first case, the fibrous matter is obtained in the form of filaments, adhering together, and producing a body of some elasticity; in the second case, on the contrary, it is precipitated in the form of membranous particles; both of them, however, when treated with chemical agents, afford constantly the same results, that is, those which belong to animal matters in general.

In young animals, the fibrous matter appears to be less tenacious in consistence than in the adult, in which the tenacity is more evident; but neither in health nor in disease is there any other difference than what respects the age; so that the fibrin separated from the blood of a healthy, vigorous person of middle age, very nearly resembles that of the blood of patients labouring under scorbutic, putrid, or inflammatory diseases.

It is the fibrous matter that contributes to the formation of the coagulum, which was a long time attributed to the loss of the natural heat of the blood; but which

is in reality the consequence of the contraction this matter undergoes on losing the principle of life.

3. Gelatin. Many very celebrated physiologists have ^{Gelatin.} supposed that the blood contained a certain quantity of gelatinous matter. Rouelle and other chemists having fought for it in vain, denied it's existence; Fourcroy however was assured that he had obtained it alone, and disengaged from every foreign body. The aqueous fluids being the natural menstrua of this matter, it may be supposed that the serum would draw it along with it, and it there remains confounded with the albumen, the neutral salts and the soda, but it is easily separated on coagulating the serum. There is therefore no doubt of it's existence. The quantity however of gelatin is very inconsiderable in the blood, and it is perhaps on this account that it's discovery has been so long prevented. It is probable, that in proportion as it is formed, a part of it separates, which is destined with the fibrin to the formation of the muscular substance. The morbid action seems to have no influence on the gelatin, for in the blood of the before-mentioned diseased patients it was found to enjoy all it's properties, and it may be observed on concluding this article, that Hippocrates and Bordeau were not deceived in saying, that the blood was melted and running flesh, since the two matters that constitute flesh are found in this fluid.

4. Albumen. Whilst the blood has not undergone ^{Albumen.} any change, this particular matter remains in solution in the serum, but on the smallest decomposition of the blood it separates into two parts the one of which unites with the serum and gives it a kind of unctuousity; the other on the contrary, joins the fibrin and colouring part. Since then, it's concretion can only take place from the loss of a certain quantity of water that dissolved it, it becomes of

consistence which it partakes of with the two bodies with which it is found mixed.

It is the concretion of the albumen that contributes to the formation of the coagulum by means of the fibrin, and as the concretion of the albumen takes place in this case spontaneously and without the aid of heat, it cannot have lost the property of being soluble in a fresh quantity of water; and this is also the reason of the coagulum being entirely soluble in water, whilst the albumen separated by heat or acids is no longer soluble in aqueous fluids.

The soda or fixed alkali appears to contribute to the solubility of the albumen. These two bodies are indeed in a sort of slight combination, since heat, spirit of wine and certain acids are capable of destroying it, and of causing the albumen to appear, which immediately loses the property of being soluble in water.

On comparing the albumen of the blood with that of the white of egg, and of other animal fluids, they are perfectly similar, at least they have the same properties, and sulphur is likewise found in them.

Of all the constituent parts of the blood, the albumen is that which seemed to undergo the greatest alterations from disease. In particular it became sensible on heating the serum that held it in solution, and it then never acquired that complete concretion which the serum of healthy blood always had when treated in the same manner. A certain quantity of liquor separated, which was easily extracted by simple decantation. This change however is not peculiar to any particular disorder, nor could differences be obtained with every precaution, that were sufficiently sensible to take any account of.

Colouring
matter.

5. Red part. This part of the blood varies infinitely in its shades. In general, the colour of the blood of youth is vermilion, whilst that of old age is darker coloured. It is likewise well known, that venous blood is

of a less lively red than arterial, and that the shades in the colour of this fluid are very numerous. It was impossible to obtain the colouring part, disengaged of foreign matter, but it appears to be always accompanied with a certain portion of albumen, to which it has a decided relation. Their solubility in water and their insolubility in spirit of wine, as well as in other menstrea, are the causes that oppose their separation, and prevent the acquirement of the knowledge that might be had of it, if it could be obtained by itself. It appears however to be the opinion of Parmentier and Deyenx, that iron acts a great part in the coloration of the blood, and that it's solution is produced in this fluid by the soda.

6. Iron. This metal is only contained in the red part of the blood, which appears from experiments to be held in solution, as observed, by the alkali, and it is this solution that produces the red colour, but what becomes of the iron on quitting the blood, chemistry has not yet been able to decide; the most extraordinary circumstance however, is, that the muscular part which is supposed to be entirely produced by the blood, does not contain the least atom of this metal.

7. Sulphur. It is difficult to determine the state in which this substance is found in the albumen, but it appears to be one of it's constituent parts. It most probably acts a great part in the animal economy, since independent of what is found in the albumen of the blood, it exists in the bile, the brain, and in all the humours where albumen is present.

8. Fixed alkali or soda. This alkali always accompanies the blood, and is in sufficient quantity always to be easily obtained from it; most probably one of it's principal functions is to favour the solution of bodies, which without it's action would remain insoluble, such as iron and albumen. It is also probable, that it's utility is

more extensive, as would appear from it's tendency to combination, and the property it has of communicating it to bodies with which it is found united. It appears to be always in a caustic state, whether in the blood or other humours of the body, and may be considered as their essential salt. In the blood it more especially becomes the *medium junctionis* of the albumen with the serum, and it's proportion in this fluid is more considerable than that of the albumen and iron.

Water.

9. Water. The fluidity of the blood essentially depends upon the water it contains, it facilitates the motion of the bodies that constitute it, and renders them proper to enter into the composition of the different parts to the formation of which it concurs. If water be composed of hydrogen and oxygen, it ought to be presumed, that it is continually forming in the animal system, and that independent of the quantity necessary to give fluidity to the blood, there is another portion decomposed during the act of circulation, the results of which decomposition contribute to repair the supposed losses either of the fibrin or albumen.

The blood does not always contain an equal quantity of water, hence it's fluidity is not always the same; but it is certain, that from it's greater or less fluidity, the least consequence cannot be drawn, so as to throw any light on the healthy or morbid state of the subject from whom the blood was drawn, since from comparative experiments on the blood of both, infinite variations were observed.

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MILK.

Milk. This is a more or less white opaque fluid, secreted from the blood in the breast of the female sex, for the support of their young during the first stage of life. The mammalia and cetacea are the only tribes that afford it; on which account they are called lactiferous animals, all others being found destitute of the organs that secrete it.

It is remarkable for containing a quantity of saccharine matter in one of it's component parts, and a much greater abundance of the earth of bones or phosphat of lime than any other animal fluid; by which it appears, that nature was desirous of affording a supply of nourishment and of osseous matter in proportion to the rapidity of

the formation and increase of the bones and other parts, during the first season of animal existence.

It's properties.

Milk, as it is drawn from the animal, has a mild faint smell, which is peculiar to the species it is taken from. This is the odour that is expressed by the vulgar saying, it smells of the cow, the goat, the ass, the sheep, or the mare. As the milk becomes cool, this aroma goes off; it is likewise expelled by exposure to heat.

To the taste, it is pleasant and more or less sweet, and although this last property is scarcely perceptible in the milk of some animals, it is however always mild. To the touch it is somewhat unctuous.

It's specific gravity is greater than that of distilled water,

When examined by the microscope, a multitude of globules are seen of unequal size, and if we may give credit to Leuenhoeck, milk is composed of transparent globules carried in the same manner as those of the blood in a diaphanous liquid.

Spontaneous separation into three parts.

Since transparency and limpidity are the most certain marks of a real solution, it might be expected from the opacity of this fluid, that a portion at least of it's contents was only suspended in it; and such is the case, for if fresh milk be left to repose some time in a cool situation, a spontaneous separation takes place between it's parts. In the first place, there arises to the surface a more or less thick tenacious substance, the *cream*. When this has been taken off, the remainder goes by the name of skimmed milk; it is then of a bluish cast, and has a less mild flavour and is more fluid than before. Some time afterwards, the coagulable or caseous part of the milk separates, which is called *curd*. And this separation is more quickly effected if the atmosphere be warm, by producing a slight acetous fermentation sooner than would otherwise have taken place. When this curd has

been taken from it by filtration, the remaining fluid is called *wey*, or the serum of milk. The coagulation of milk does not take place in vacuo.

A separation of the caseous part, or curd, may likewise be effected artificially by means of chemical reagents; thus milk is coagulated by all acids except the carbonic and weaker acids; by certain vegetables, as galium, valantia cruciata, madder, thistle, &c. But according to the observation of Jacquin, these only act when added to milk in the cold, or when it is mixed with a cold aqueous infusion of them; for if these vegetables be boiled in milk, or thrown into hot milk, the coagulation, instead of being promoted, is rather retarded; nor has the infusion of these plants prepared by heat, their decoction, or even their distilled water any effect upon milk; by mucous bodies, as gum arabic, albumen, sugar, &c.; by all salts, more especially if they contain an excess of acid; as cream of tartar, salts of succinum, benzoin, &c. by all metallic solutions; and lastly, by alcohol and all spirituous liquors, whilst this coagulum is rendered more perfect by means of heat.

Artificial
separation
by acids,
vegetables.

The mild alkalis likewise coagulate milk, but in a different manner from the substances before mentioned, for they unite with the butter and cheese, and form a kind of saponaceous mass, separating from the milk in the form of dense white flocculi, which by continued ebullition become yellow, and at length brown.

Alkalis,

The caustic alkalis dissolve the coagulum or caseous part, and hence they make milk more fluid instead of coagulating it.

Lime water produces an imperfect coagulation.

The electric fluid appears to thicken it more or less.

Fresh milk neither changes the colour of the tincture of litmus, nor of the syrup of violets; hence it is neither acid nor alkali,

With respect to other substances mentioned by authors as producing various effects on milk, they will be given when each kind of milk is treated of individually. It may be added, at the same time, that this fluid is so susceptible of variation, not only in different species of animals, but in the same female at different times, from numberless circumstances; such as age, season, nutriment, &c. that it is almost impossible to meet with two milks that do not differ from each other.

Heat at first renders milk more fluid, and it becomes concrete at the freezing points.

Exposed to
heat

If fresh milk be exposed to a gentle distilling heat on a water bath, there arises a fat pellicle, which is succeeded by others, a part of which being attached to the sides or bottom of the vessel, dries and torrifies, communicating to the fluid a disagreeable empyreumatic taste and odour, commonly called *potrether*, and which it cannot afterwards be deprived of; it may, however, be prevented by frequent stirring the fluid; if the serum is to be obtained, it is necessary to take away the pellicles as they appear, and replace the fluid in proportion as it evaporates by distilled water.

The serum obtained by this method is, on filtration, very clear, and by spontaneous evaporation affords sugar of milk, and the other salts it held in solution. These pellicles do not form without the contact of the air, since a combination with oxygen is as necessary in this case as in the spontaneous coagulation of milk. If these pellicles be washed, they appear like semipellucid membranes, very much resembling those that line the shells of eggs. They form the caseous part, and very soon become putrid on exposure to the air.

If the ebullition of the milk be so accelerated as to prevent the formation of the pellicles, and the products be examined, there is found in the receiver an insipid clear

water, impregnated with the aroma of milk, which soon becomes putrid. The part remaining in the retort is either in the state of a moist or dry extract, which, Extract of milk. when dissolved in hot water, affords the original milk, but destitute of its peculiar aroma. If this extract be exposed to a stronger degree of heat, as on the sand bath, it affords an empyreumatic acid and oil, ammonia, and hydrogen and carbonic acid gases. The residuum in the retort is a black coal, the ashes of which, on incineration, give potash, muriat of potash and phosphat of lime, with a little iron.

New milk, if left to itself, undergoes the acetous fermentation; this in cold weather requires several days, but in a warm temperature, twenty-four hours are sufficient for that purpose. It appears, that the milk of the ruminating class becomes sour sooner than that of the others: the milk of the sheep is said to undergo this fermentation the soonest; and that of the mare, the latest. Milks, when rendered sour, are used by different nations as drink or food. Acetous fermentation.

Milk becomes suddenly acid from sudden changes in the atmosphere, and from stormy seasons, but this propensity to change may be in some measure prevented by previous boiling, it will then keep for several days, but boiled milk, however, sooner passes into the putrid state.

If fresh milk be put into a moderately warm place, Vinous. and often stirred, so as to prevent a spontaneous separation of its parts, it undergoes the vinous fermentation, and on distillation, a strong spirit is obtained; this is sooner brought about by the addition of a fermenting substance. According to Stipriaan, the greatest quantity of spirit was obtained from the milk of the cow; whilst Plenck affirms, the mare, from the greater abundance of sugar it affords, ferments the soonest.

Putrid.

There is no animal fluid, if the gastric juice be perhaps excepted, that undergoes the putrid fermentation with so much difficulty as milk: according to Stipriaan, the milk of the cow remained four two months in the middle of summer without any signs of putridity; that of the ass three months before any ammonia was produced; likewise the human milk was kept many months without becoming putrid; hence the difference of nourishment appears to have no influence in this respect.

The next part of this subject that is to be considered, is an examination of the three parts which are the products of spontaneous separation in milk, *viz.* cream, curd and whey.

Cream.

Cream. This part of the milk which is the lightest, and consequently arises to the surface; contains a fat or oil, which, on being exposed to the air, the mechanical operation of churning, and a certain degree of warmth, is procured in a concrete form called butter; for which *vide* animal oils.

The remaining fluid is white, and is the serum of milk, containing some of the caseous and butyraceous parts; it is sweet or sour according to the sweetness or acidity of the cream employed, and is called *Butter-milk*. According to Stipriaan, the milk of the sheep affords the greatest quantity of cream; then follow the human, and those of the goat and cow, whilst the ass and mare give the smallest quantity. It appears, however, that the cream of the sheep and goat is the thickest; and that from the milk of the human female, of the ass, and of the mare, the thinnest. All bodies which render fat oils soluble in water, impede the separation of butter. The extremes of heat and cold do the same.

Curd.

Curd. This coagulated part of milk, when fresh, is a white jelly-like substance, somewhat elastic, but is of more or less consistence according as it contains more or

less serum; it breaks readily with a rough fracture; is nearly without smell or taste; insoluble in water; becomes hard in hot water; is readily dissolved by acids, forming with the vitriolic and muriatic brown solutions; and with the nitrous acid, a yellow solution; but the marine acid does not dissolve it so readily as the other two. It is likewise easily dissolved by the alkalis, pure or carbonated; but the vegetable has the least effect upon it. During its solution with the caustic mineral alkali, a putrid volatile alkaline smell arises.

By distillation, it affords a tasteless water that easily putrifies; on increasing the heat, it blisters, swells like burnt horn, affords hydrogen and carbonic acid gas, ammonia, partly fixed, partly fluid, and a heavy stinking empyreumatic oil. The coal is in great quantity, and difficult to incinerate. The ashes contain lime, and phosphat of lime, to which some chemists have added iron. Curd or cheese, on exposure to a strong heat, softens, melts in some measure, loses its opaque white colour, acquires a transparency and toughness-like horn, throws out more or less of its butyraceous or oily parts, and when cool, becomes hard and brittle. In short, curd has all the properties of albumen.

Curd is of various consistence in different milks; that of the milk of the goat and cow is solid and elastic; of the ass and mare less solid; that of the sheep only glutinous; whilst the cheesy part of the human milk is never solid, but always fluid, and its separation is attended with difficulty, and seldom spontaneous.

Curd, when salted and compressed, forms common cheese. If this be prepared from new milk, containing all its cream, the cheese is rich and good; but if from skimmed milk, which contains but a little butyraceous portion, the cheese is meagre and bad. In the making of cheese, since the coagulation of milk is imperfect by

repose alone, from the whey still containing too many of the caseous particles; and as the time it takes is long and uncertain, the artificial means of coagulating it have been resorted to. For this purpose, the moist or dried stomach of a calf is generally employed, known by the name of rennet. It is the fourth stomach of the ruminating class, and it's power is owing to it's gastric juice, which is secreted from the middle coat of that organ.

Whey.

Whey. The serum of milk, or the fluid that remains after the separation of the cream and curd, is of a yellowish colour; has a sweet agreeable taste; and when the milk has undergone no previous acidity, and prepared without boiling, possesses the odour of milk. It is always turbid, and is best clarified by the white of egg. It is called *sweet whey*. It is sometimes used in medicine, and is prepared by adding half a drachm of pulverized cream of tartar, or a few tea spoonfulls of lemon-juice to a pint of milk, brought to the boiling point, and this is continued until all the caseous particles are separated, it is then to be clarified by the white of egg, or deprived of it's superabundant acid by a little calcareous earth.

Sweet.

By distillation of this whey on the water-bath, the same water is obtained as from new milk, and there remains a mass, which, when freed from it's cheesy, and other adhering parts, shoots into white rhomboidal crystals, termed sugar of milk.

Sour.

If, on the contrary, the milk has been previously sour before coagulation, the liquor that remains is called *sour whey*. Sweet whey, likewise by rest, will undergo the acetous fermentation; and we are informed, by Jacquin, that by the addition of a small portion of spirit of wine, and subsequent fermentation, a true vinegar of milk may be prepared. This acidity of milk is attributed by chemists to the saccharine part, for they

find that the sooner the whey is become four by spontaneous fermentation, the smaller is the quantity of sugar that is left, vide *Lactic acid*.

The sugar of milk is of an opaque white colour, has an insipid sweetness and somewhat earthy flavour. It is perfectly soluble in four parts of boiling water. When distilled by a strong heat, it exhibits the same appearances as common sugar. Rouelle extracted from one pound of this salt when calcined, from twenty-four to thirty grains of ashes; three-fourths of which were muriat of potash, and the other fourth carbonat of potash. Placed on a lighted coal the sugar of milk melts, swells, exhales an odour of sugar candy, and burns like common sugar. These properties induced chemists to suspect that, like sugar, it would afford the oxalic acid by means of nitric acid, which Scheele confirmed by experiment; but it required a great deal of nitric acid to obtain it. He procured five drachms of oxalic acid from four ounces of sugar of milk, and he observed, on diluting with water the residuum of the sugar of milk treated in this manner, and on filtering it, in order to evaporate and crystallize the oxalic acid, that a white powder remained on the filter which had rendered the solution turbid; and on examining this acid, he found it to be a peculiar acid, the *sacchrolactic acid*, for which vide *Acids*.

Milk, therefore, from the above analysis, consists of the following proximate component parts: a fat oil, an albuminous substance, an essential salt and water. Some chemists, and particularly Macquer and Morveau, have looked upon it as a real animal emulsion, in which the oil is put into a saponaceous state by the intervention of the mucous or caseous part and saline principles; but the necessity of oxygen in the separation of the butter and albumen, and the other physical properties it possesses, are, perhaps, sufficient proofs of milk not being an emul-

sion. It appears, however, that milk may in some measure be compared to the juices of expressed fruits; it is opaque, mild, saccharine, nutritive, and contains an essential salt. Like them, a decomposition readily takes place, which gives rise to products analogous to those of wine, *i. e.* an ardent spirit and vinegar. It was also observed by Parmentier and Deyeux, that the thickest milk required the longest time for the fermentative process to take place; that it furnished the greatest quantity of ardent spirit, and that this spirit was not evident on distillation before the milk has passed to the acetous state, which equally happens to cyder, perry, &c. It is to facilitate the fermentescible parts becoming acid that the Russian Tartars add a certain quantity of oatmeal to their mares milk, and that they take care not to distil it until the mixture is strongly sour, for by this means they obtain more spirit. Milk likewise unites a number of properties analogous to the lymphatic and albuminous matter; hence it is employed with advantage to clarify wines, and particularly ratifiats, to which it communicates that marrowy flavour not to be procured by any other means; for this purpose, however, it must be fresh, otherwise it does harm. It is therefore from its undergoing the vinous and acetous fermentations, as well as the difficulty of becoming putrid, that milk approaches to the nature of the vegetable kingdom; and from its containing a quantity of albumen in the caseous matter, that it resembles the animal kingdom.

The remote component parts of milk are therefore oxygen, hydrogen, carbon, azot, soda, phosphorus and lime, to which some chemists have added iron.

HISTORY OF MILK.

It would be in vain to attempt to give any satisfactory

account of the first knowledge of the component parts of milk, and it's spontaneous changes. Milk was undoubtedly made use of as an aliment, by the earliest inhabitants of antiquity ; for history informs us, that the riches of Abraham and Isaac consisted for the most part in their herds. It is likewise very evident, that cream, from it's Cream. so soon appearing on the surface, must have been very early observed, and from it's delicious flavour, must, no doubt, have been esteemed a great dainty ; but there is reason to believe that butter, which forms so leading a Butter? feature in this fluid, was a much later discovery. It is true, that the translators of the bible have made use of this word, but the best critics are of opinion, that the word *camea* signifies milk or cream, or four thick milk, and not butter, as it alludes to something liquid. "When I washed my steps with butter, and the rock poured me out rivers of oil." Job. ch. 29. v. 6. "He shall not see the rivers, the floods, the brooks of honey and butter." Ibid. ch. 20. v. 17. It is likewise the opinion of the learned Michaelis, that the translators of the bible who lived two hundred years after Hippocrates, and resided in Egypt, and who have translated the word by *Butyrum*, meant cream. The oldest mention of butter, according to professor Beckmann, though very obscure, is by Herodotus, in his account of the Scythians. "These people," says he, "pour the milk of their mares into wooden vessels, cause it to be violently stirred or shaken by the blind slaves, and separate the part that arises to the surface, as they consider it more valuable and delicious than that which is below it." Hippocrates, who was nearly the contemporary of Herodotus, mentions the same, but in a much clearer manner.

"The Scythians pour the milk of their mares into wooden vessels, and shake it violently ; this causes it to foam, and the fat part which is light rising to the sur-

face, becomes what is called butter ; the heavy and thick part which is below, being kneaded, and properly prepared, is after being dried called *hippace*. The whey or serum remains in the middle." This passage, it would seem, denotes very clearly butter, cheese, and whey. Hippocrates prescribed it as a medicine under the name of *pikerion*, which becoming obsolete is translated by Galen, *butyron*. The word does not occur in Aristotle. In Dioscorides, we are informed that fresh butter might be melted and poured over pulse and vegetables instead of oil, and employed in pastry instead of other fat substances. Galen remarks, that cows milk produces the fattest butter ; that of the goat or sheep is less rich, and that of the ass yields the poorest. Hence butter must have been very little used or known by the Greeks or Romans in the time of Galen, *i. e.* at the end of the second century. According to Galen and Pliny, the word *βουτος* or *βουτος* is composed of *βου* an ox and *τος* cheese; cheese was known to them much earlier, and perhaps they may have looked at first upon butter as a kind of cheese, as *τος* once signified, according to Bechmann, any coagulated substance. The Greeks used the milk of sheep and goats much earlier than cows milk. From what has been said, as well as from other documents, it appears, that butter is neither a Grecian nor a Roman discovery, but that the Greeks were made acquainted with it by the Scythians, the Thracians, and the Phrygians; and that the Romans first learned it from the people of Germany. It is also pretty certain, that when they had been taught the art of making it, it was only employed in their baths, and particularly in medicine ; and it may be observed, that Columella is the first Latin author who uses the word *butyrum*. The Romans used it in general to anoint the bodies of their children, and the ancient Burgundians besmeared their hair with it. Neither the Greeks nor the

Romans used it in cookery, or the preparation of food; they accustomed themselves merely to oil, and even at present, it is rarely employed in Italy, Spain, Portugal, and the southern parts of France, where it is sold in the apothecaries shops for medicinal purposes. We may therefore conclude, that the ancients were unacquainted with the method of kneading, washing, and salting butter, in order to render it as firm as it is now a days. It was always in an oily state and fluid, they always speak of something liquid; thus the ancients poured it out like oil, and their elephants drank it; but the moderns cut, knead and spread it.

With respect to cheese and whey, we are informed, Cheese and Whey. that cheese was prepared even from the most ancient times in Syria, Palestine, and Egypt, from the milks of the cow, the camel, the goat and the sheep; and that it was a food particularly delightful to the Scythians, and the Greeks; and not only Hippocrates, as before mentioned, but many of the ancients clearly describe the ferosity of milk or whey; amongst which are Columella and Dioscorides; they describe the method of separating it by agitation, by coction, or by mixing with the milk vinegar, or the branches of the fig tree; and they likewise give some account of what they called *oxigala*, which is a preparation formed by the addition of some salt or more simply by the mixture of sour with fresh milk. In the time, however, of Pliny, it appears, that some of the barbarous nations living on milk were either ignorant of the benefit of cheese, or if it was known to them, they disregarded it. Pliny seems to have looked upon this with astonishment, for at the same time, they were accustomed to thicken their milk into a sort of pleasant sour curd like a syllabub, and as he expresses himself, to churn butter from it, which is the scum and cream of milk, and much thicker in consistence than the whey. We

are informed by this celebrated Roman author and natural historian, that the milk which is afforded by those animals that have teeth in both jaws is not fit to make cheese, because it will not curdle. This has been certified by the best chemists of modern days with respect to that of the human female, which is in general found incapable of coagulation, although it has been denied by others. Pliny likewise informs us that the milk of the cow affords more cheese than that of the goat, being nearly twice as much; and that at Rome, the best cheeses came from the provinces of Nemausum, and from the villages of Læso and Baux, but that it was necessary to eat them green. Excellent cheese was likewise made in Dalmatia, Drinaldi, and Vatusum, in the province of Ceutonia, and in the Sæditian territory. In his days, the best foreign cheese came from Bithynia, whilst that sent from France had a phsyicky taste and a kind of aromatic favour. With respect to any other knowledge the ancients had of the other component parts of this fluid, it was perhaps only a superficial acquaintance with the saccharine part, and limited to the organs of taste.

State of
analysis of
milk in the
middle of
the last
century.

The analysis of milk seems to have been but very imperfectly understood towards the middle of the last century. Swammerdam and Leuwenhoeck had examined it's globules by the microscope; it was known that warmth assisted in it's coagulation, and that in tempestuous weather it became four much sooner than in calm seasons; that this took place more readily in ruminating than non-ruminating animals, and that the milk of the carnivorous class, when fed entirely on flesh, was not coagulated at all. Homberg, Boerhaave, du Hamel, Ratty, Navier, Egeling, Geymuller, and Wulliamoz, had made some observations and a few experiments upon it; it's coagulation by acids, by alcohol, by alum, was known; the specific gravity of the different milks had been examined,

the quantities of the cream, butter, and cheese they contained, in some measure ascertained; it had been subjected to the power of caloric, and from it, on distillation, we are informed, much water was obtained; this was rather empyreumatic, an acid spirit afterwards, a fetid oil, and a splendid friable coal remained at last, in which was a fixed salt. Butter and cheese had likewise undergone a slight examination; an acid water with the butyraceous odour, a thick fluid oil, and another kind that was tenacious and red, were said to have been produced from the first, and on the incineration of the coal, a fixed alkali was obtained which was supposed to be the vegetable; the second, or caseous part, was said to be of a mucilaginous nature, that it gives an acid phlegm, a bluish oil, somewhat empyreumatic, then thick, black, and so weighty as to sink in water, and that the coal is afterward difficult of incineration. It was thought that the caseous part was the most powerfully nourishing of the milk; that the oily or butyraceous part had a laxative property, and that the aqueous part was of a refrigerating nature; with respect to the serum of milk, or its whey, it had been long known that it contained a saccharine part, which was said to be of an animal nature. This had been first mentioned by Fabricius Bartoletus, and afterward described by Lewis Jesti, though the Brachmans had been before accustomed to procure it from milk, as well as other sweet juices. Navier had extracted it from the human milk, and Hoffmann from that of the ass.

Very soon after this period, more numerous experiments were made to procure a more exact analysis of milk; its physical properties were better defined, and the action of reagents on different species of it, were more successfully investigated by Geoffroy, Bergius, Valtelen, Spielmann, Seheele, &c. a few of which

it will be necessary to mention, without going into any extensive detail. With respect to the quantities of cream, cheese, whey, and the butyraceous parts of different milks, Spielmann has examined those of the human, the goat, the sheep, and the cow; he informs us, that two pounds of the first contained one ounce and a half of cream, which afforded six drachms of butter, half an ounce of a tender cheese, and ten drachms of a fixed matter which remained after inspissation of the whey; the rest was water. From the same quantity of the milk of the goat, he obtained one ounce of cream, three drachms of butter, three ounces and three drachms of cheese, and six drachms of a fixed matter; hence it contained more cheese, and less water and oil than the human. The same quantity of sheep's milk afforded him two ounces of cream, fourteen drachms of soft butter, four ounces of cheese, and ten drachms of fixed matter; hence he found it to be fatter and more caseous than the human, but not so thin. From the same quantity of cows milk he procured three ounces and half of cream, six drachms of hardish butter, three ounces of cheese, eleven drachms of fixed matter; hence it exceeded the human by far, both in butter and cheese. He found the milk of the ass to be the heaviest, and that of the goat the lightest.

According to Voltelen's experiments, thirty ounces of human milk afforded him only two drachms of cream. The same quantity of asses milk gave him only three drachms of cream, but no butter, three drachms of tender cheese, an ounce and half of a fixed matter on inspissation; and he found it contained more fixed part and water, and to be less rich in butter and cheese than the human milk. Two pounds of mare's milk afforded three drachms of cream, no butter, seventeen drachms of cheese, and

nine of fixed matter; which is, therefore, richer in the last matter, but contains less oil and water than the human milk.

With respect to the spontaneous acidity of milk, that of the human, which is said to afford more cream in a shorter time than any other, is not subject to this fermentation, if the person has been accustomed to flesh diet; for, according to Bergius, some of it, after having been placed in a heated oven for many weeks, and being covered with a very thick cream, had contracted not the slightest acidity. On the contrary, we are informed, that when the person fed only on a vegetable diet, it coagulated on the eighth day, whilst that of the cow becomes acid in three days and a half.

With respect to the coagulation of milk by acids, according to Voltelen, the three mineral acids, as well as aqua regia and vinegar, soon coagulate sheep's milk in the cold; but cream of tartar coagulates it more slowly. He found that asses milk is coagulated by vinegar, cream of tartar, spirit of sulphur, aqua regia, nitrous and vitriolic acids, in the cold; and that rennet from the calf, and smoking muriatic acid, required the assistance of heat: that human milk was neither coagulated at its natural temperature, nor in the cold, by lemon juice, cream of tartar, rennet, spirit of vitriol, nor by the three strong mineral acids; on the contrary, in a boiling heat, a yellow porous coagulum was separated from it by the nitrous acid, and a thick white one by the muriatic; the first of which, on digestion with nitrous acid, became of a bluish and bluish-grey colour; the other remained unchanged; whilst, according to Bergius, it became coagulable by vinegar, after the person had lived on vegetable diet, which must be continued at least eight days. According to Scheele, the

vegetable acids produce more cheese from cow's milk than the mineral.

Scopoli obtained from one ounce of cow's milk, coagulated by vitriolic acid, seventy grains of reddish coagulum, and on filtration, a perfectly transparent whey; with muriatic acid, 51 grains of the first, and the whey not quite so transparent; with nitrous acid, 46 grains of yellow coagulum and turbid whey; with acid of arsenic, 61 grains of whitish coagulum, and the whey evidently transparent; with fluor acid, 40 grains of the same, and a similar whey, which, however, deposited a yellow coagulum; with phosphoric acid, 40 grains of white coagulum, and some clear whey, from which a little more coagulum fell to the bottom; with acid of sugar, 43 grains of whitish coagulum and turbid whey, which still deposited some coagulum; with acid of tartar, 48 grains of the same, without sediment; with animal acid, 25 grains of the same, which on repose deposited more; with the acid of wood, 28 grains of whitish coagulum, and turbid whey; with vinegar 36 grains of reddish coagulum, and clear whey, with some little coagulated deposit; and lastly, with lemon acid, 40 grains of yellowish coagulum and turbid whey, from which some more coagulum separated.

Alkalis.

With respect to *alkalis*, we are informed by Egeling, that cow's milk is coagulated either by fixed or volatile alkalis.

Scopoli obtained from one ounce of cow's milk mixed with mild vegetable alkali, forty-eight grains of white coagulum and turbid whey; with caustic volatile alkali, forty-six grains of yellowish coagulum and turbid milk, which, after filtration, separated more coagulum; and with mild volatile alkali twenty-four grains of white coagulum and turbid whey. According to Morgagni, lime water does not coagulate cow's milk. According

to Voltelen, sheep's milk is not coagulated by caustic volatile alkali; by caustic fixed alkalis and lixivium sanguinis only by heat; but by common, fixed, and volatile alkalis, light flocks are produced in it; and by a boiling heat, larger flocks. Mixed with lime water, both in heat and cold, it remains unchanged. From asses milk, caustic volatile alkaline spirit, produced only extremely small flocks; the common volatile alkali in the cold, somewhat larger; soap lees had a less effect; lixivium sanguinis, and much sooner common alkali, afforded thick lumps of coagulum; lime-water had no action upon it, but by no means prevented it's coagulation by acids and rennet.

According to Bergius, the human milk was neither changed in it's natural temperament, nor at a boiling heat by spirits of hartshorn, volatile alkali, nor by spirit of sal ammoniac; nor by oil of tartar, or fixed alkali, either in it's common temperature or in the cold; mixed, however, with it at a boiling heat, and digested, they changed it's colour to a yellowish green, which gave immediate rise to a thick pellicle, and an odour of sweet cheese. Nor was this milk changed by soap lees in the warmth, from Voltelen's experiment; but lixiv. sang. although it did not coagulate in the cold, yet by a boiling heat produced a strong coagulation, with an evident change of colour. By the same heat it was coagulated by lime water. We likewise are informed by Voltelen, that the human milk, the sheep's, and the asses milk, and the cows milk, according to Boerhaave, on being boiled with fixed alkalis, become by degrees more yellow, afterwards reddish, and at last blood-coloured, brown red, and dark red. After some time small flocks are separated from this red fluid, which is covered with cream, and this takes place immediately if vitriolic acid be added. The human milk, when boiled with lixiv. sang.

deposits a caseous matter in forty-eight hours, whilst a yellowish red tough pellicle is formed on it's surface. and the fluid itself is darkish. According to Silvius's conjecture, it was by such means that the conversion of chyle into blood was brought about.

Neutral. According to Voltelen, the human, cows, sheep's, and asses milk, neither in the cold nor by heat, are acted upon by solutions of saline neutral salts, such as vitriolated tartar, nitre, common salt, sal ammon. spiritus, Minder. nor by borax. It, however, appears, that sal ammon. promotes the separation of the cream and whey in the milk of the sheep, and that common salt coagulates milk, although Gourraigne affirms, that it prevents the coagulation of it by acids. With respect to the earthy neutral salts, bitter salt has no effect upon milk. According to Voltelen, alum has no effect on human milk, either in the cold, or with the assistance of heat; but decomposes that of the ass and the sheep when boiled with it.

Metallic solutions.

The same chemist informs us, that most of the metallic solutions decompose the different sorts of milk, in a longer or shorter space of time: that solutions of iron and it's vitriol act upon them in the cold: that sugar of lead, which decomposes asses and sheep's milk immediately in the cold, appears only to hasten the separation of the cream in the human milk: that the vitriolic and nitrous solutions of quicksilver produce a quick coagulation and a red colour. The solution of corrosive sublimate coagulates them in the warmth. The acid solution of copper, decomposes asses and sheep's milk, but only colours human milk, and the volatile alkaline solution of copper has no effect in coagulating milk of any species. A solution of silver coagulates milk, and colours the whey, first of a rose colour, then of a purple red. We are informed by Navier, that arsenic appears to pre-

vent the coagulation of milk. Voltelen likewise informs us, that asses milk was not coagulated by the mercurius gummosus of Plenck, in the cold, but was very strongly so by the assistance of heat; this, however, is supposed to have arisen from the gum, which, according to Scheele, as well as the albumen of the egg and sugar, coagulates milk.

According to Leonhardi, the human milk mixed with Alcohol, alcohol, at first did not coagulate, but began in about twenty-four hours, by the means of heat. The alcohol had no effect on the milk, when sedative salt or camphor was dissolved in it; on the contrary, the alcohol coagulated asses milk a little in the cold, and sheep's milk very strongly. With spiritus camphori, both the kinds of milk undergo no change; camphor even appeared to prevent their coagulation.

Scopoli obtained by alcohol, twenty-five grains of white coagulum, and the filtrated whey was afterwards milk white.

The astringent vegetables decompose in the cold, the human milk, and those of the cow, the ass, and sheep. According to Scheele, the same effect takes place with the Peruvian bark. According to Bergius, human milk is neither coagulated by saliva, nor bile, nor by the white of eggs.

With respect to the best methods of coagulating milk, so as to procure the whey as pure as possible, we are informed by Frederick Hoffmann, that four whey, (serum lactis acidulum) is procured by adding one drachm of cream of tartar, or one or two tea-spoonfuls of lemon juice to one pound of boiling milk, and to keep it boiling afterwards until the caseous part is perfectly separated. It is then to be clarified with the white of eggs, filtrated, andedulcorated by the powder of crabs-eyes.

Vinous milk (serum lactis vinosum) is prepared by

adding four or six ounces of good four white wine to a measure of boiling milk, and after coagulation filtrating the liquor.

Another kind of whey, called *doppelmolken* by the Germans, (*serum lactis duplicatum*) is obtained by equal parts of fresh milk and butter milk, being mixed together when warm.

According to Pærner, it is much better for the cheese and the whey, to coagulate milk by rennet; by this means he obtained the best and sweetest whey, and it afforded a greater quantity in general, than when cream of tartar or lemon juice was used. If either of the last substances be employed, it is necessary to add crabs eyes, or a similar substance, to the four whey obtained, to edulcorate it, which give it an unpleasant earthy taste. Besides, some part is dissolved by the acid which remains after filtration. Pærner, therefore, gives the preference to rennet, which may be prepared in different manners, of which he mentions two. The stomach of a sucking calf being blown up whilst the coagulated milk remains in it, it is gradually dried; the two ends are then to be cut off, the coagulated milk, which is nearly dried, must be thrown away, and only the stomach employed, of which a piece about a finger's length is to be cut off when required, put into a glass, and three or four spoonfuls of fresh water added to it, in which it is to remain from sixteen to twenty-four hours. A spoonful of this is then to be taken, and mixed with a canne of the skimmed milk to be coagulated; it is then placed on a moderate fire, so as to be made warm until it is coagulated, which takes place in a quarter, or at farthest half an hour. It is then to be filtrated, and the whey is very pleasant and not acid. The other method is to take the fresh stomach of a sucking calf, cleanse it, put the coagulated milk in again, add a little common salt, and fill the stomach half

full of milk. Having tied the two ends, it is to be placed in a basin and more milk added to it, a little more salt added, and to be left to repose a couple of days in a moderately warm place; which, according to Leonhardi, ought to be from 70° to 100° of Fahrenheit. Of the milk which has now become coagulated in the basin, a spoonful is to be taken and used as before mentioned. When this is consumed, the stomach is to be opened to let a little run out, tied again, and the basin filled as before with milk, and covered. By this means a stomach will last nearly a year; care must, however, be taken that it become not putrid. Hence it appears, that Pœrner, as well as Macquer, was of opinion that the coagulation proceeded from the coagulated milk of the stomach, and that the cause of this was an acid. It is scarcely necessary to mention, that the coagulation is now well known to be caused by the gastric juice, and that the stomach is used in a dry state.

According to Macquer, whey is not only the aqueous part of the milk, but contains likewise all the component parts of it which are soluble in water. It has a peculiar taste, which becomes stronger on evaporation. This flavour is somewhat saccharine and saline. It contains an extractive saccharine matter, and hence is capable of the spirituous fermentation. It also contains other kinds of salts, which are mentioned by Leonhardi, such as the vegetable alkali, the acid of milk, phosphat of lime, and digestive salt.

According to Boerhaave, the water which comes out on the distillation of milk is somewhat empyreumatic and nauseating to the taste. Voltelen found this water of the same smell as the milk, and mild in flavour, but unpleasant. Besides this water which he obtained from the distillation of the human, asses, and sheep's milk he obtained an acid spirit, a light and heavy oil; and in the

Distillation
of milk.

asses, after incinerating the coal, a fixed alkaline salt, a sort of neutral common salt, an earthy substance; and some particles of iron. He likewise observed in the distillation of the milks of the ass and sheep, that a real volatile alkali arose after the acid spirit. Beccaria had observed the presence of this alkali in milk, and Hahn had observed it in that of the cow; but in Voltelen's experiments, there were no traces of it in the human milk. From the last milk, however, there was extricated a very large quantity of an elastic gaseous matter even during the coming over of the water, which at times threatened to break the vessel, of this air he did not find any in the two other milks.

Sugar of
milk.

Bartholdi.

Testi.

Williamoz.

It is related by Kempfer, that the Brachmans were acquainted with the process of making the sugar of milk: whether this was the case or not, Fabricius Bartholdi, an Italian physician, is the first who has mentioned this essential saccharine substance of milk in his *Encyclopædia*, printed at Bologna in 1619, under the title of Manna; or Nitre of Milk: and it is from this book that Etmuller has borrowed his description of it. In 1698, Testi, a Venetian physician, published a *Memoir of the Sugar of Milk*, in which he appears to attribute the discovery of it to himself: he speaks with great zeal of its medical virtues, particularly in the cure of the gout, and in an alchemical style describes the method of preparing it. Different accounts of the same sort have been given by Werlofchnigg, Vallisnieri, Fickius and Cartheuser. We are informed by Williamoz, that the manner in which Cartheuser prepared it did not succeed with him; he praises in the highest style the sugar of milk prepared by one Creuzius, and esteems it the best mode of any which the Swiss make use of, and which he regrets is not understood elsewhere. It is known that in Switzerland this sugar has long been made a part of their traffic; they

fell two sorts of it, one in the form of tablets, the other in that of crystals. He has given us the method employed in the Alps for making both varieties. For the first, the milk must be previously skimmed, it is then coagulated by rennet, filtrated through a linen cloth, and the whey evaporated over a slow fire to the consistence of honey; when it is sufficiently thickened, it is put into moulds of different figures and dried in the sun. For the second, these tablets are dissolved in water, clarified with the white of eggs, then filtrated and evaporated to the consistence of syrup, and left in repose to crystallize. These crystals, on examination, are found to be composed of cubic masses, very brilliant and white, and are attached to the sides of the vessel in strata; if the remaining liquor be again exposed to heat, and evaporated, other crystals are obtained on evaporation, and this operation may be separated a third time. The first crystals are of a dazzling white, the second of the colour of straw, and the last of a bran colour; these by solution, clarification, filtration, and crystallization, may be brought to the same dazzling whiteness and degree of purity as the first. According to Wulliamoz, the properties which he found the sugar of milk to possess, and the products it afforded him on decomposition, prove it to be of a saponaceous nature; it unites oils with water, and it has a great resemblance to the juice of the sugar cane.

Haller has, according to Morveau, given the best method of preparing the sugar of milk. The whey is to be clarified with the whites of eggs, and continually kept boiling until that part is separated, in order to thicken it before it has contracted any acidity. The crystals are then neither acid nor alkaline, but an essential salt as perfect as the sugar of the cane, which like it renders oils miscible with water, prevents the cream separating from the milk, and in short has the properties of soap. Haller

believes that the milk of all animals contains this salt, but not in the same proportions. According to his account, four ounces of sheep's milk afforded from 35 to 37 grⁱ. of sugar.

Goats 47—49

Cows 53—54

Human 58—67

Mares 69—70

Affes 80—82

Lichten-
stein.

Lichtenstein has examined and analysed the different sugars of milk, which are sold at various prices in Switzerland, and has more particularly distinguished six species, of which an account will be given. He extracted this sugar both from sweet and sour whey; he found that the residue of the saccharine crystallization, or what remains after the crystallization of the sugar of milk in *sweet* whey, is pituitous, somewhat empyreumatic, and tastes saline; that it is easily dissolved in water, changes the syrup of violets, tincture of litmus, and the solution of Brunswick, green. When mixed with liver of sulphur, no strong smell arises; rubbed with fixed alkalies, unslacked lime or minium, it gives a volatile alkaline smell; and mixed with vitriolic acid, a smell of muriatic acid; it gives a precipitate of luna cornea when mixed with the solution of silver; and plumbum corneum and a white precipitate in the solutions of lead and mercury. On digestion with spirit of wine, and then mixing with vitriolic acid, there arises a fine acid smell; but mixed with fixed alkali, a volatile alkaline smell. The gelatinous residue from *sour whey*, in which the acid sugar of milk has crystallized, is according to the same author sourish, and likewise somewhat alkaline to the taste; it colours the syrup of violets and tincture of litmus red, effervesces with common alkalis, colours the blue solution of Brunswick green immediately of an emerald green; decomposes liver of sulphur with the common disagreeable smell;

communicates to alcohol digested with it a yellow colour, and after the evaporation of the alcohol, there remains a brown, pituitous, saline, sour tasting substance, which effervesces with fixed alkalis, emitting a volatile alkaline smell, and with the vitriolic acid, an acid smell. What the alcohol will not dissolve does not effervesce with alkalis, gives no acid smell with the vitriolic acid, and deposits after solution in water a light yellowish earth.

Clarified sweet sugar of milk (*saccharum lactis purissimum*) which is crystallized from sweet whey, according to Lichtenstein, is of a milk white colour, consists of small crystals which are semitransparent, forming regular parallelopiped prisms, terminated by a regular pyramid parallelogramically rectangular, which at the temperature of 10° or 11° of Reaumur has a specific gravity of 1.543.

Water at the same degree dissolves about the 7th of it's weight.

It is insoluble in rectified spirit of wine.

It's flavour is rather sweetish, it has no smell.

It does not change the colour of turnsole, or syrup of violets, or the solution of Brunswick green; it does not render turbid the solution of corrosive sublimate, nor decompose the calcareous hepar of sulphur. When pulverised with potash, lime, or minium, it gives out no ammoniacal odour, nor does the vitriolic acid disengage from it any vapour of the muriatic acid.

It does not decompose the solutions of silver, lead, or mercury.

It is completely soluble in the nitrous acid; after evaporation, a fermenting mass is found, which, on being dried and burnt, shows the same properties as the pure sugar of milk.

Exposed to a gentle fire in an earthen vessel, there arises an odour of burnt sugar, it swells considerably, and

becomes a black thick mass, which at first hardens in the air, but afterwards becomes soft, and when applied to the tongue tastes sweetish like the sugar of milk itself, and leaves a moderately bitter flavour in the mouth. In a stronger heat, it burns to a black spongy coal, which exhales an odour of burnt tartar.

The sugar from four whey (*saccharum lactis acescens*) is the sugar of milk mixed with galactic acid. It is of a yellowish colour, in small crystals; it's flavour agreeably acid, and it's aroma fatty and acidulous.

It is more readily dissolved in water than that from sweet whey.

It effervesces with alkaline and earthy substances, by which it loses it's acidity.

It reddens the syrup of violets, and the infusion of litmus, and destroys the blue shade of the Brunswick green.

It colours yellow, rectified alcohol, and this as it evaporates takes away all it's acidity; water itself extracted from it several times does the same. It precipitates the hepar of sulphur, with a strong hepatic aroma.

The fire acts upon it as on pure sugar of milk.

Lichtenstein likewise describes a sugar of milk united with oily particles, and it is this which shoots during the first crystallization. It appears of a yellow colour, and becomes rancid in time; when, however, deprived of the oily parts, it is real pure sugar of milk. He likewise mentions another sugar united with an oil and common salt, and which is of the last crystallization. It is of a yellow colour, saline flavour, gives a muriatic acid odour on adding the vitriolic acid to it; precipitates silver, lead, and mercury white from their solutions in nitrous acid, and in time becomes rancid. He mentions a third sugar united with oil, common salt, and sal ammoniac, which, besides the foregoing properties, possesses that of feeling

constantly pituitous and moist, and affords a volatile alkaline smell, on being rubbed with fixed alkalis; and lastly, another sugar which besides being united with oil, common salt, and ammoniac, is found tainted with a mucus or a caseous part, which is not fixed and crystallized, but mealy, becoming in time mouldy and rancid, and depositing a caseous matter on it's solution in water. This is the most imperfect sort of the sugar of milk. An acid is likewise to be found united with all these impure kinds, when they are prepared from sour whey.

Repeated solutions and evaporations of sugar of milk by a strong heat decompose it in part; it scarcely preserves it's sweetish taste, but has an earthy and disagreeable flavour. It very difficultly dissolves in water; it has the appearance of chalk, and when mixed with an alkali, it deposits much more earth than pure sugar of milk.

To purify such impure sugars, either chalk, calcareous marl, or spirit of wine may be employed.

Leonhardi was informed by his friend Geutler, an apothecary in Switzerland, that the peasants there made use of alum, which they bought in large quantities, to coagulate their milk with, and by which they obtained very white sugar of the first crystallization; whilst Prince, an apothecary at Neuchatel, who prepares by unknown means a beautiful sugar of milk, without the medium of any foreign substance, entirely rejects this addition.

When this sugar of milk is perfectly pure, it is quite white, and nearly tasteless.

Rouelle, who has made many experiments on the saccharine part of milk, agrees very much with those of Lichtenstein, respecting the sugar obtained from sweet whey. In his paper published in the *Journal de Médecine* for March 1773, he has given the following account of them.

Whey obtained without cream of tartar affords on

evaporation to the consistence of a syrup, and placed in cold, crystals of the salt or sugar of milk. This mother ley, he informs us, may be evaporated to the third time, and fresh crystals obtained; but it then contains some crystals of digestive salt of Sylvius. The remaining ley or rather coloured liquor, consisting of the mucous part, is changed sometimes by means of the mucus into a jelly; it also contains an extractive matter. This ley, mixed with twice it's quantity of distilled water, had no effect on the syrup of violets; nor did a diluted acid effervesce with it.

If concentrated vitriolic acid effervesced somewhat with the last crystallization, or it's ley, there arose some muriatic acid vapours, which Rouelle attributed to the salt of Sylvius.

The sugar of milk on distillation afforded, 1st. a little phlegm, 2d. an acid, 3d. an oil, 4th. a large coaly matter remained, resembling that from the distillation of saccharine mucous bodies, as honey, manna, sugar candy, &c. It had no fixed alkaline properties, nor did it effervesce with acids as the coal of tartar does. It afforded scarcely any ashes on incineration, which were still black, and hence contained undecomposed coal. United with water, it changed the syrup of violets green; and did not, however, effervesce with acids: but Rouelle thinks it contained an uncommonly small quantity of fixed alkali; consequently the products of this sugar are the same as those of starch and sugar candy, a very few circumstances excepted.

The last crystallization, and it's mother ley, afforded by the lixiviation of their coals a little digestive salt of Sylvius, and a very small quantity of fixed alkali, which appeared to Rouelle to proceed from the extractive matter.

The sugar exposed to a strong heat in an iron kettle melted in part, and was of the colour of burned sugar.

(caramel): the smell was that of burnt honey, manna, or common sugar. He found two parts of sugar candy to require one of water for solution; and for the solution of the sugar of milk, scarcely more than an equal quantity was necessary. The salt from the incineration of the coal of cows milk afforded him fixed vegetable alkali; the rest was the salt of Sylvius; for being decomposed by the vitriolic acid, the muriatic acid was separated, and vitriolated tartar obtained. By the nitrous acid he obtained nitre. He found six grains and half of alkali in one pint of milk.

From the experiments of Beaume, it appears, that Beaume, from the third crystallization, he obtained crystals of common salt, and from the mother ley, which produced no more sugar, he procured a fixed alkali without incineration. He obtained the last also after the distillation of the sugar. It remained in the retort, and he found this sugar of milk to have many properties in common with cream of tartar, excepting it's not being sour. According to Beaume, the whey of the milk of the cow, evaporated to three fourths, affords the sugar of milk.

The strongest acids had no effect upon it, at the same time he looks upon it to be of a saponaceous nature. On exposure to fire in a retort, he obtained empyreumatic oil, and a fixed alkali remained.

By a second evaporation, he obtained a salt resembling the first, which was, however, decomposed by the mineral acids. The third evaporation of the whey afforded crystals of common salt.

A fluid remained, incapable of affording more crystals, it contained fixed alkali and a little extractive matter, the alkali he obtained without incineration.

Each pint of whey afforded seven or eight drachms of these salts, the origin of which Beaume attributes to the vegetable nourishment of the cow.

It appears from the experiments of the two last French chemists, that in their examination, they attended more to the residuum of the evaporation, than to the action of reagents on the sugar of milk. For a more exact analysis of it, we are indebted to Scheele and Hermbstadt, which will clear up any doubts respecting it's component parts.

Scheele.

Scheele's Memoir on this subject was published in 1780, in Sweden. In this dissertation, the ingenious chemist proves that the sugar of milk affords the same products as any other sugar; but the most remarkable is, that the empyreumatic oil has an aroma approaching that of the benzoic acid, or salt of benzoin. By distillation with the nitrous acid diluted, he procured real saccharine acid as in common sugar; but from this experiment he was conducted to the discovery of the *sacchrolactic acid*; for on treating the sugar in the same way as that for obtaining the saccharine acid from common sugar, he found a quantity of white powder, which troubled the solution, and which he got upon the filter on filtrating the solution, previous to it's exsiccation to obtain the crystals of the saccharine acid. The quintal afforded him fifteen pounds and half of saccharine acid; and twenty-three pounds and half of the white powder.

Hermbstadt

This memoir of Scheele, it appears, had not reached Hermbstadt, when the latter published, in 1782, his examination of this salt and it's acid. He did not use the fuming nitrous acid, but preferred the double aqua fortis, simply rectified on the nitre, and from which he had separated the more aqueous particles that first arise. Having extracted it, he found in the retort when cooled a deposit of a considerable quantity of earthy matter, and the surface covered with a pellicle of the same nature; besides this, he obtained real saccharine acid. With four parts of the sugar of milk, and twenty-six of nitrous acid of 1,320 specific gravity, he obtained out of the

quintal only fourteen and one sixteenth of the acid of fugar, and forty-three and three fourths of the above mentioned white powder. It may be remarked, that the aqueous solution of the fugar of milk mixes with vitriolic acid as well as mild vegetable alkalis, without affording any deposit. On distillation, he obtained from two ounces of the fugar of milk some very thick white vapours, six drachms of a clear yellow, strong, and empyreumatic acid fluid; a few drops of a dark red oil, and six drachms of coal; which, on exposure to a red heat, lost two scruples; and from which solution in mineral acids he precipitated with mild vegetable alkali a little calcareous earth.

From the experiments, therefore, of these two chemists, it appears, that the fugar of milk well prepared and rectified contains no disengaged acid or alkali, or mineral neutral salt; that it's essential constituent parts are, 1st. a real fugar like that of the cane, *i. e.* the radical of the saccharine acid united to the syrupous acid which exists perfectly formed; 2d. another substance of an earthy appearance, and which modifies the exterior characters of the ordinary fugar.

EXAMINATION OF THE DIFFERENT KINDS OF MILK.

The different kinds of milk that have undergone the investigation of several of the best chemists of the present time, and upon which some very curious and instructive observations have been made, are six in number, viz. the milk of the cow, the human milk, those of the ass, the goat, the sheep, and the mare. But although much has been done in order to gain a complete knowledge of their component parts, and of the causes that constitute their differences; yet there are many circumstances attending

Six different species of milk examined.

each species, which future experiment and observation must unfold.

Milk of the cow. Since this is the most universal of any, not only when used crude as an aliment, but for a variety of culinary purposes, it is not extraordinary that it should have been oftener the subject of analysis; and we have, perhaps, a more exact account of it's nature, properties, and contents, than those of all the others put together. It has been more particularly examined of late by the French chemists, from whose labours this, as well as the other parts of the same subject, will be for the most part extracted.

**Colour,
smell, and
taste.**

The milk of the cow, when first drawn, is a white opaque fluid, it has a peculiar pleasant smell, is of a sweetish, somewhat fattish taste; but these properties depend upon a variety of circumstances, such as the peculiar temperament, food of the animal, &c. Thus immediately after calving, it partakes more of the animal nature, and it receives a disagreeable and peculiar flavour from various vegetables. We are informed that all plants of the garlic kind, many of the umbelliferous, the horse mint, cabbages, turnips, autumnal leaves, give it their peculiar flavour. According to Anderson, it is not uncommon to find the milk of farrow cows sensibly saline to the taste, particularly that which is first drawn; and that, at last, it becomes perfectly sweet, the saltness gradually decreasing from the beginning, and not to be observed when about one half was drawn off; and perhaps the same circumstance may be found to take place in milk flavoured by vegetables. Cows that feed on the leaves of maize give an extremely mild and saccharine milk; and fed on the potatoe plant, it is insipid. Likewise, the Alderney breed, and the Alpine cows afford a very rich milk both in colour and consistence, whilst the northern cows give an aqueous and bluish milk: the milk of Sardinia is so

rich as to afford one half of cream, whilst that of Catalonia yields very little. In summer milk is more or less yellow, and in winter white. With respect to it's colour, we are informed by Teflier, of the French National Institute, that he has observed milk newly drawn from the cow, and of a beautiful white colour, to become blue in the course of two or three days; this was attributed to some plants of the nature of woad or indigo, on which cows will sometimes feed; and Dr. Garden found, that after cows had eaten the same plant in an indigo field, the cream of their milk was of a most beautiful blue colour. Boiling, although it in some measure dissipates the disagreeable taste of plants, had no effect on the colour. Cows that feed on the madder plant, give a milk that appears streaked with blood; and after eating the fruit of the cactus opuntia, milk of a reddish colour. Gugenmus gave the madder plant formed into hay to his cows, which ate it readily; their milk was somewhat reddish, and the butter and cheese acquired by these means, in winter, an agreeable colour.

The milk of the cow, in it's ordinary state, boils at a degree above that of boiling water.

Fixed air has no effect upon it, neither has sedative salt. Effects of reagents upon it.

The vitriolic acid coagulates it into thick lumps, which are scarcely afterward dissolved by potash; the other acids act in a similar manner, such as the nitrous, muriatic, phosphoric, and the coagula are redissolved by an alkali.

Vinegar, whether concentrated or not, coagulates it, and the lumps are again dissolved by alkalis, and become of a rose colour.

The oxalic acid, according to Stipriaan, only coagulates it when srewed in the form of a powder.

The carbonat of potash converts it into a jelly, and if heat be employed, it changes it's colour (or rather the

colour of the whey) to a yellow red, and at last a brown. Caustic alkali dissolves it with a yellowish colour.

Ammonia thins it, and on boiling heightens it's colour.

Lime water thickens it a little.

Neutral salts make it thinner, previous to their thickening it.

According to Stipriaan, highly rectified spirit of wine does not coagulate it.

Infusion of the dried stomach of a calf coagulated it.

The electric fluid thickened it somewhat.

On subjecting it to the vinous fermentation, Stipriaan obtained from it by distillation a hot spirit.

When the milk is coagulated by artificial means, a mild agreeable serosity is produced of a lemon colour, which is the whey or serum.

It's specific gravity to that of pure water was in summer as 1028 to 1000.

Distillation. We are informed by Parmentier, that on distilling the milk of cows fed on different food, he obtained eight ounces of a clear and colourless fluid from eight pounds of each milk, but the odour and flavour were similar to the food of the animal, that lived for nearly one month in a temperature of 16 to 18° of Reaumur. These fluids began to prove turbid and viscous, and their odour was a little fetid; that obtained from the milk of the cow fed on cabbage underwent a more sudden and sensible alteration than the others, and was sometimes the first to become putrid. These liquors, arrived at the viscous and opaque state, became perfectly transparent again at a heat of 25°, whilst some slight white filaments were formed, (and this is the case with liquors obtained by the same means from flesh, white of egg, and other ani-

mal substances ; all the liquors, which are at first very limpid, become turbid at the end of a certain time, lose their odour, and acquire another which is in general very disagreeable). On filtration, they become perfectly clear, without flavour or odour, and on evaporation to dryness, little or nothing was left to collect. The residuum was thick, greasy to the touch, of a yellowish white, mild, and even sweet flavour, and to it Hoffmann gave *Franchipan*, the name of *Franchipan*. By diluting this in boiling water, a milky liquor is obtained, known in France by the name of Hoffmann's whey. On distillation, an aqueous fluid, a very fluid yellow oil, an acid, volatile alkali, a thick black empyreumatic oil, and an inflammable gas are obtained. The carbonated matter, in the retort, is difficult to incinerate. The ashes change the blue of violets green ; when sulphuric acid is poured on them, vapours of muriatic acid arise.

It appears that, on changing the food, although for the better, the quantity of milk becomes very evidently diminished, and it's increase is only perceptible after having been accustomed to the new regimen for several days. The aroma appears to form a constituent part of the milk. To this, it may be added, that the odour of the plants, distinguished in the volatile parts of the milk, are not perceived in the fixed parts.

Change of
food lessens
the quantity
of milk.

Milk taken from the cow immediately after calving is called *beastings*, (*colostrum primum*;) it is of a yellowish colour ; sometimes mixed with streaks of blood ; it is thick and clammy ; it's taste is like other milk, but somewhat mucous.

Beastings.

It's specific gravity to that of water is 1072 to 1000.

On the fire it soon coagulates and becomes of a whiter colour.

Milk of the second drawing is not so yellow, thick,

or heavy; it's specific gravity was found by Stipriaan to be to water as 1052 to 1000. This is more difficult to coagulate, and stirring prevents it's coagulation.

Properties
of it.

Beastings is coagulated by all the acids; the vitriolic makes it whiter and very thick; the muriatic and nitrous likewise thicken it, especially the former. Vinegar only coagulates it in it's concentrated state.

Alkalis thicken it, and give it different colours.

The neutral salts render it more thin.

It is coagulated by alcohol.

Rennet changes the first drawn milk into a jelly, and coagulates the second.

Sixteen hundred parts of the first afforded 187 of cream, 48 of butter, and 300 of cheese; and the same quantity of the second gave 64 of cream, and 202 of cheese.

Exposed to the air in summer, they both become highly putrid in six or eight days, with the odour of putrid flesh.

More ani-
malized
than ordin-
ary milk.

This milk, especially the first, is more animalized than the ordinary milk, and it's liquid part, or whey, agrees very much with the serum of the blood; it, however, contains very little of this part, on the contrary, a great deal of cream and butter. Independent of the caseous part, it is very heavy, scarcely ever becomes sour, but undergoes the putrid fermentation proportionably quicker. Stipriaan looks upon beastings to be milk united with a quantity of serum of the blood.

Cream.

Cream of the cow. This, on standing, becomes thicker and of a deep yellow colour; it loses it's pleasant smell for one that is disagreeable; and, according to Parmen-tier, it became covered over with a green effervescence in about the space of three weeks, whilst the under part had a caseous flavour. It afforded, on distillation, the same products as those extracted from fat bodies; at first

a yellowish oil, of a strong and penetrating odour, with some drops of a liquor slightly acid; afterward volatile alkali; then a charcoal of difficult incineration, but no fixed alkalis were found in it.

We are informed by Dr. Anderson, that the quantity of cream, collected from the milk of the cow, is different according to the time of it's being drawn, and that a small quantity of milk which comes the last contains about sixteen parts more cream than the same quantity drawn the first, at the same milking; that the cream is much richer, it's colour of a deep orange, whilst that of the other is white. He informs us, that the cream in the first case was a thin tough film, thinner and perhaps whiter than common writing paper, whilst in the last drawn cup it was of a thick butyraceous consistence, and of a glowing richness of colour, as he expresses it, which no other cream is found to possess. From these experiments, "it appears," says Dr. Anderson, "that a person, who by bad milking of his cow loses but half a pint of his milk, loses in fact about as much cream as would be afforded by six or eight pints at the beginning; and loses, besides, that part of the cream which alone can give richness and high flavour to his butter."

Anderson's
observations.

If milk be put into a dish and allowed to stand till the cream arises to the surface, that portion of cream which arises first is richer in quality and greater in quantity than that which rises in a second equal space of time; and that which rises in the second interval of time is greater in quantity and richer in quality than in the third equal space of time, and so on. The cream that rises decreasing in quantity and declining in quality as long as any rises to the surface.

Dr. Anderson found, that thick milk always throws up a smaller proportion of cream it contains to the sur-

face than thinner milk, but the cream is of much richer quality. If water be added to this rich milk, it is found to afford a much greater quantity of cream than it otherwise would have done, but it's quality is debased: Neither does milk which has been previously agitated by carriage afford so rich a cream, nor in such quantity as when it is left to repose after having been drawn. In this case, it is supposed, that the loss of cream will be nearly in proportion to the time elapsed, and the agitation it has suffered since the time of being drawn.

With respect to the separation of cream from the milk, it appears, that it takes place with the greatest regularity in a temperature of from 53° to 55° of Fahrenheit, which temperature it is necessary those who are engaged in the dairy should be acquainted with; for when the heat exceeds 63° this operation becomes very difficult, for the milk is apt to become sour and to coagulate suddenly without permitting the separation of the cream; if, on the other hand, the milk is kept in too cool a temperature, as under 40° , the cream separates from it with great difficulty and very slowly, and acquires a bitter and disagreeable taste.

Milk, in the autumn, is much richer and more coagulable, and gives more cream than in the spring. It likewise gives it's cream sooner in summer than in winter. This arises from the heat which, by giving more fluidity to it's particles, permits them to act according to their specific gravity. If, however, this heat be too strong or sudden, an acid is produced which coagulates the caseous part before the cream has had time to separate. This is the case in stormy weather.

Fourcroy suspects, that the electric fluid is the principal cause of this effect; for a good conductor passing in the middle of a dairy prevents, or at least very much retards this coagulation during stormy weather. Cow's

milk requires twice the time in winter to give it's cream to what it does in summer. According to Fourcroy, four or five days are sufficient in summer, and eight or ten in winter, before all the particles of cream can arise; it must likewise be kept at eight or ten of Reaumur; it will not cream at all at zero, and it freezes a few degrees below it.

The butter of the milk of the cow is in general of a yellow colour; but sometimes it is as white as fat or ^{Butter.} lard, and is of an inferior quality. The colour, however, depends on the serum, the physical state of the animal, and other circumstances. If the cream be got from milk, exposed to too low a temperature, the butter when extracted will be pale, very small in quantity, of little taste, very hard and brittle, and of no value. Butter, likewise, extracted from new cream, has a more agreeable flavour than when extracted from old; for to make butter of the best quality, it will not only be necessary to separate the first drawn milk from the rest, but likewise to take only the first cream that is separated from the best milk, as it is only the first rising cream, that is of the best quality. Thus the richness of the highland butter is attributed, by Dr. Anderson, to the practice of giving the first drawn milk to the calves, and keeping the rest for the dairy; and the quality and richness of the butter will be improved in proportion to the smallness of the quantity of the last drawn milk. Another circumstance in the separation of butter from cream is, that it does not take place till after the last has attained a certain degree of acidity; if, therefore, it be agitated before that acidity has begun, no butter can be obtained; and, according to Anderson, the agitation must be continued until that sourness be produced, after which the butter begins to form; hence, the cream ought to remain in the vessel appropriated for keeping it, until it has acquired that proper degree of acidity by which butter is easily

extracted, by a very moderate degree of agitation ; and by this process only can very fine butter be obtained. In summer, while the temperature is warm, if the agitation be continued till the acidity is produced, the process will be long and tedious, and the butter is generally of a soft consistence, and gluey to the touch ; whilst, if the same be attempted during the cold in winter, butter can scarcely in any way be obtained except by the application of a great heat, which sometimes assists in producing a very inferior sort, white, hard, and brittle, resembling that before mentioned ; when the milk has been exposed to too low a temperature, it has very little taste, and is unfit for culinary purposes. Cream, therefore, which has been kept three or four days in summer, is in excellent condition for producing butter ; and Anderson is of opinion, that from three to seven days will be found in general to be the most proper time for keeping cream before it is churned.

Robinson's
observations.

According to Mr. George Robinson, butter from cream is much richer than that from milk, but is less in quantity, and does not keep so long sweet ; a good cow will produce from seven to ten pounds of butter every week.

With respect to the yellow colour of butter, it is pretended, by some people, that it is owing to the aliments ; but it is well known that cows, when feeding on the same food and in the same pastures, sometimes give yellow, and at other times white butter ; hence it appears, that it is in some measure to be attributed to the constitution of the animal. At the same time, it cannot be denied, but that the aliments may have some share in it's coloration. The contact of the air has likewise an effect in colouring butter, for sometimes that which is quite white acquires a yellow colour a certain time after it's preparation ; and butter, on being cut, will some-

times be found to be much less coloured internally than externally.

According to Fourcroy, it is necessary to wait some Fourcroy. time after the cream is formed, before the butter is extracted from it. It appears to him, that the cream absorbs a portion of oxygen from the air, which thickens it, and diminishes the attraction of the butyraceous particles for those with which it was united in the liquid cream; such are principally the caseous particles and those of the gelatinous mucilage, a proportion of which is separated from the cream by the mechanical operation of churning. It appears, that the air very much facilitates the separation of the cream from the milk, for when milk is placed in vacuo it does not give up its cream so readily, nor is the cream so thick and abundant as when exposed to the air at the same temperature. It appears that cream, taken from milk of twenty-four hours standing, requires at least four times longer to give butter than that of eight days, and four times more motion; for it is necessary that it take in a few hours from the atmosphere in the one case, what it had in the other imbibed in seven days, for which purpose the points of contact must be multiplied and renewed in proportion, which is brought about by churning. These facts appear to Fourcroy to prove, that the butter is not wholly formed in milk; that it is there in a state of oil, which must absorb a certain quantity of oxygen before it can become concrete.

Parmentier is not of the same opinion. "Whatever Parmentier. doubts," says he, "may be formed of the preexistence of butter in cream, it must be allowed that cream has the general properties of oily matters. It is specifically lighter than milk; is unctuous to the touch; it spots cloth like fat bodies; it grows rancid, and at length contracts a strong taste, which gives reason to suppose

that butter is contained in cream, but under a semi-combination, which agitation alone can destroy." He has endeavoured to support this opinion by experiment. He endeavoured to deprive cream of it's serous part, which constitutes it's fluidity, without altering it's properties; for which purpose he procured a certain quantity upon several leaves of grey paper, which, after being impregnated with the serous part, left the cream as solid as butter. It was then collected and diluted with a certain quantity of distilled water, sufficient to restore it to it's former fluidity; and on agitating the fluid, the butter separated as usual; the serosity was only extremely insipid; which, according to Parmentier, was a proof that the saline matter dissolved in the serum does not serve as an intermediate body to unite the butter with the cream. Some drops of vinegar added to fresh cream, in order to attack the caseous part, had no effect in promoting the extraction of the butter, but retarded it, and the last retained a little of the caseous part into the bargain. This experiment likewise proves, according to this chemist, that the promptitude with which the butter separates from four cream depends less on an acid developed in this fluid, than on the species of fermentation which has produced this acid.

Best sorts of
English butter.

They who are desirous of knowing the method of making good butter should attend to the methods which are employed in the best dairies; such is the *West country* method, as Dr. Anderson has called it. They first deposit their milk in earthen pans, and let them remain twelve hours in summer and twenty-four in winter; they are then removed to stoves, heated for that purpose with hot embers; here they remain till bubbles arise and the cream changes it's colour, this is called *scalded* cream. It is then removed with care to the dairy, where it remains twelve hours longer, when it is skimmed, and the

cream is churned. The Cambridgeshire salt butter is made nearly in the same manner, and is in the highest esteem. This, when deprived of it's salt by washing, is sold at a high price in London as fresh butter. Nearly the same method is pursued in Suffolk and Yorkshire, and the butter is not much inferior to that of Cambridge, being often sold in London for that butter. The food is often found to affect the butter, as wild garlick, charlock, or May weed, turnips and rape. A great part of the Epping butter, according to Dr. Anderson, is made from the cows that feed, during the summer months, in the forest, where the leaves and shrubby plants greatly contribute to it's flavour. The mountains of Wales, the highlands of Scotland, and the moors, commons and heaths of England, produce excellent butter where it is properly managed; and though not equal in quantity to that produced from rich meadow land, yet is superior in flavour and quality.

To this short digression on the making of butter in the dairy, may be added this method of preserving it: Preservation of butter. To preserve butter more effectually than salt from any taint of rancidity, the following prescription has been used; One part of sugar, one of nitre, and two parts of the best Spanish salt, are to be finely pulverized together, and kept for use; one ounce of this is to be mixed thoroughly with sixteen ounces of the butter, as soon as it is freed from the buttermilk; it is then to be put into a close and perfectly clean dry vessel, from which the air is to be carefully excluded, and it will remain good for many years.

Butter must be divided into small portions and well Rancidity. washed, until the water ceases to be milky, otherwise some portions of the cream will remain, by which it soon loses it's delicate flavour for a strong disagreeable sharp taste, vulgarly called *rancidity*. Butter appears to

be more susceptible of this spontaneous change than other oily matters. This may be retarded by keeping it in a cool place, or mixing salt with it. Parmentier washed, more or less perfectly, equal quantities of butter of his own making from excellent cream, and when placed in the same temperature they became sooner or later rancid, according as they were more or less well washed. To prove, in a still more evident manner, the presence of cream or milk in butter, and it's action on this oily body, two ounces of fresh butter were melted by a gentle heat in a small pot, and an equal quantity of rancid butter in another vessel; after cooling, a small portion resembling cream was found at the bottom of the vessel; that of the first had a mild flavour, whilst that of the second was very sharp. This effect became infinitely more sensible on increasing the fluidity of the butter, by adding equal parts of oil of sweet almonds. Supposing these experiments not sufficient to prove the influence of the caseous matter on the rancidity of butter, it is sufficient to pay attention to the daily practice of dairymaids, who, on melting their butter, find the caseous matter precipitated to the bottom and torried; likewise, by kneading rancid butter with water, it will soften it's strong taste. With respect to rancidity proceeding from an acid, as some chemists have imagined, it is proved by experiment, that neither rancid butter, nor old cheese, either coagulates milk or reddens the blues of vegetables.

Pure butter, exposed to a gentle heat, melted and well washed, does not become rancid so soon as other butter, but it is not so agreeable to the taste; and it appears probable to Fourcroy, that it is on this account a certain quantity of cheese is always left in it, which renders it opaque, and which may be separated by gentle fusion; the butter, likewise, is more marrowy after fusion. Fourcroy put some fresh butter of the market into a tube of

one inch diameter, stopped it at one end, and plunged it into hot water; at the temperature of 28° it separated into three parts; the cheese was at the top, apparently drawn there by some air blebs which appeared to adhere to it more than to the other matters; the pure butter was in the middle, and water in the inferior part.

Butter, melted by this gentle heat, has not the same properties as before; its colour, flavour, and texture are changed; it is become semitransparent, and granulated; its flavour is insipid and similar to that of fat: these changes which butter undergoes in melting, are caused by the separation of the caseous part and the mucilage. *Vide oils, article butter.*

Buttermilk. We are informed by Parmentier, that Butters milk. this fluid resembles perfectly skimmed milk, in all its physical, chemical, and economical properties. When it is acid, as happens in the summer months, or when it is taken from old creams, it has a flavour manifestly sharp, and is less white than common milk; it is then clarified with extreme quickness, the developed acid coagulating one part of the caseous matter, and the solution the other. Buttermilk is not so sharp as the acid cream from which it is taken, owing to the percussion during churning having either destroyed the acid or forced it to combine with the caseous matter; buttermilk, therefore, differs from milk only by being completely deprived of its butyraceous matter.

Skimmed milk. Milk, when deprived of its cream, Skimmed milk. has neither that dead white colour which it has in winter, and yellow colour in summer, nor that unctuous consistence and sweet flavour which it has when fresh drawn; and as its density is decreased it is boiled by an inferior heat. It is likewise capable of dissolving a greater portion of sugar, and other saline bodies. It is owing to the absence of the cream in this milk that it is preferred for

whey, the clarification being more complete, and it does not spoil so soon. If skimmed milk be left in the open air, or even in a bottle, it loses its sweet savour, contracts a sharpness, and changes into a serous liquor; in the midst of which floats a coagulum which is easily separated by decantation, especially if the vessel be exposed to a gentle heat, and is the caseous part.

If this milk, which has just begun to turn sour, be put into a vessel and placed in some heated water for one night, this caseous matter will be separated into a thick creamlike substance and occupy the upper part, which is not much less in quantity than one half of the milk; when this is well done, it appears to be as rich and fat as real cream, and is only to be distinguished from it by its sourness; it is eaten with sugar, and is esteemed a great delicacy; it however requires practice to make it nicely, and give it a proper creamy consistence; the degree of heat and other minute circumstances greatly affecting the operation.

Skimmed milk being exposed to heat on the *baln. marin.* pellicles arise as before-mentioned, article *milk*. In proportion as they are formed, the milk becomes thick, hence, water must be added to preserve its fluidity; when it ceases to give these pellicles it is transparent and fluid, and no longer to be curdled by acids; in short, it is whey, or the serum of the milk. Being left six days in a vessel, these pellicles gave an insupportable odour. On the fire, they blister and expose an odour of burnt horn, and afford on distillation the same products, viz. phlegm, light oil, ammonia, and an empyreumatic oil; a charcoal remains of difficult incineration. One of the most remarkable properties of these pellicles is, to be dissolved by caustic soda. The solution is of a deep red. This colour Parmentier thinks is due to the carbon, which is first separated and then dissolved by the soda.

The caseous matter, being the same as the pellicles just mentioned, possesses their properties; when fresh and moist, it is in part soluble in the alkalis, but when excicated they act very little on it. The manner in which fixed alkalis act on fresh curd merits a particular examination. When flakes of cheese are put into liquid and caustic potash or soda, they become transparent, and are dissolved, whilst a great quantity of ammonia is disengaged, as observed both by Fourcroy and Parmentier; the same takes place with the gluten of wheat, and animal substances, as flesh. This ammonia appears to Fourcroy to be formed at the moment of the action of the alkali, for fresh cheese has no character that indicates its presence; it neither changes blue vegetable colours green, nor gives ammonia at a mild temperature. It appears, therefore, that during the time the fixed alkalis tend to unite with a certain portion of cheese; its principles immediately change in their attractions; a certain quantity of its hydrogen and azot combines apart to form ammonia; the water contributes much, for the production of ammonia does not take place in dried cheese.

That portion of cheese which the alkali holds in solution gives the liquor a brownish yellow colour, which becomes brown on the application of a little strong heat; in the last case a small quantity of carbon is deposited. This matter may be separated from the soda and potash by an acid; but then it no longer possesses the ordinary properties of cheese. It has a black colour, melts in the fire like a thick oil, becomes dry no more, but remains greasy. It appears that the azot and hydrogen are first disengaged to form the ammonia, whilst the hydrogen and oxygen becoming more abundant in the caseous matter, give it its oily characters, so that its solution by the alkali forms a sort of soap.

According to Parmentier, if this combination of the

caseous matter with soda be decomposed by an acid, an hepatic odour is disengaged. He found that the vitriolic acid has very little action on the caseous matter. The fuming nitrous acid dissolves it at a boiling heat, but distilled vinegar he found to be the acid which (contrary to Scheele) the most completely dissolved it.

Scheele has shown that the acids in coagulating cheese dissolved a part of it in proportion to the quantity of acid employed. According to Fourcroy, the caseous part has a stronger attraction for some acids than for others, and in general for the vegetable acids, as vinegar, lactic acid, and amongst the mineral acids for the diluted sulphuric. It has likewise a strong attraction for the sweet serum of the milk, since this liquid by whatever means it has been clarified, always deposits some of it on passing to the acetous state.

Whey.

The flavour of this fluid, when fresh, is sweetish and somewhat saline, and when filtrated, possesses the greatest limpidity. Mixed with the fixed or volatile alkalis a white deposit is formed, which is a portion of the caseous matter held in solution by an acid. On the addition of an acid, it is expelled.

Whey is used in the bleaching of linen. It is left eight or fifteen days in large vessels of this fluid, and taken out perfectly bleached. In this case the acid of the whey is decomposed, and the oxygen acts on the colouring matter.

Serum, evaporated and placed in a fresh place, affords white crystals, which are the sugar of milk. Parmentier found no fixed alkali in the mother water, only the muriat of lime was present. Hence he concludes with Rouelle, that fixed alkali is not essential to milk, and that when found in it, it is, like all the neutral salts, carried there by the nourishment or drink of animals.

The best cheeses in England, such as the Stilton, the ^{English} Cheshire, and the Gloucester, are made from the milk ^{cheeses.} of the cow, and their difference appears to depend more on the manner of making them, than on any peculiar properties of the milks. According to Parkinson, the Stilton is made of the curds from four and sweet milk mixed together, and the whey pressed lightly out; and the richness depends in some measure on the quantity of cream. It is afterward turned often, and not dried too quickly. Cheshire cheese is made of new milk, and its rich flavour and mellowness are owing to an addition of sweet beef suet, or any other which is poured into and mixed with the curd, with a sufficient quantity of salt to keep it from rancidity. It is found that the hotter any kind of cheese is put together, the sounder it will be; and the colder you put it together, the richer it is, and the sooner it will decay. Another sort made of this milk, and of great celebrity, is the Cottenham, or Eddish cheese; it is thin and soft.

HUMAN MILK.

THIS milk is of a slight bluish colour, its flavour mild and saccharine, and of a sweetish odour.

Its specific gravity is to distilled water as 1029 to 1000.

Exposed to the air in a fresh place, its surface becomes covered over with a thick very white matter analogous to cream. From this cream Parmentier could procure no butter by agitating it for several hours; it was then left in a temperate place, when on the second day a very clear colourless liquor was observed at the bottom of the vessel, and on the surface was a thickish fluid, very white and of a mild and unctuous flavour, but butter could not be ^{Exposure to the air.}

Distillation. separated from it. It was then put into a retort and distilled, which forced over some phlegm, a strong empyreumatic oil, volatile alkali, an acid, and inflammable gas; the liquor, therefore, on which this analysed matter swam may be looked upon as a butter milk; it's transparency was not changed either by acids or spirits of wine. By insensible evaporation it afforded a saline residuum, found to be sugar of milk, mixed with some caseous matter. Human skimmed milk placed in rather a warm temperature did not coagulate in five days, it became, however, turbid from the evaporation, and sensibly acid. On letting the evaporation continue, crystals of sugar of milk were formed, and there remained at last a thick mother ley, which, evaporated to dryness, afforded muriat of soda. When heated for pellicles to appear, they arose successively as in the milk of cows, and the rest was serum.

Coagulation.

All the methods of coagulation used in cows milk succeeded, except vinegar, and the mineral acids very much diluted with water.

Curd.

It appears that the longer a milk is drawn from the time of lying in, the more caseous matter it contains, and then it is coagulated by acids; but the coagulation is always viscous, and never acquires that gelatinous consistence observed in the caseous matter of the cow. The cream of human milk soon after lying in is very small in quantity, but it increases as it recedes from that time;

Cream.

this cream is always of a dead white colour, which in a short time becomes of a thick consistence, without acquiring, however, that unctuous appearance which characterizes the cream of the cow. The observations which Parmentier has made on this milk are highly deserving of attention.

It's consistent parts difficult to ascertain.

“ Perhaps,” says this chemist, “ there is no species of milk the products of which vary so much as the human,

hence the insufficiency of every comparative analysis with that of other females. At each instant of the day, this fluid changes it's state, and the changes it undergoes are sometimes so marked, as to astonish the most experienced observers. We were at first so much struck with these differences during the same day, that we were apprehensive the milk might have been diluted with water. To avoid this suspicion, we analysed only that which had been drawn in our presence. But the consequences being still the same, we concluded, that it can never be in the power of the chemist to determine the quantities of each of the constituent parts of this fluid in a manner sufficiently positive to obtain a term of comparison, that will not be variable, since it is impossible to find two kinds of this milk perfectly similar."

The cream appears to be in a greater abundance in human milk than in that of the cow, and it differs from it very essentially in it's component parts. In that of the cow the butyraceous particles are as it were mixed with the caseous part of the serum; and agitation alone is sufficient to produce the butter; but in the human cream, the caseous matter is not only simply mixed with the butter, but it is so combined as to appear impossible to separate it. Besides, the human butter is most probably less solid than that of the cow, because the cream which contains it only acquires by percussion a thickish consistence; perhaps it is likewise to the small disposition which the butter has to take a concrete form, that the impossibility of it's separation is owing, and the property it has of remaining combined with the caseous matter from the greater affinity of their particles. "In short," says Parmentier, "to be convinced that the caseous matter and butter exist in human cream, it is sufficient to know that the cream very soon grows rancid, and that the products it gives by distillation in the open fire are precisely the same

Cream compared with that of the cow.

Butter.

as those from the cream of a cow treated in the same manner." The property of the human milk, in not being always subject to coagulation by acids, appears to depend on the small quantity of caseous matter it contains, and it's extension in this fluid; and this explanation is confirmed by Scheele's experiments, which prove that cow's milk, diluted with six parts of water, loses the property of coagulation. It also appears that the caseous part adheres very slightly to the serum; since by repose alone, it is found in great part to separate from it in the form of exceedingly tender molecules adhering to the sides of the vessel. Another character which distinguishes this milk from that of the cow, is the saccharine flavour; yet the quantity of sugar the human contains is scarcely sensibly greater. Perhaps the cause of the great development of the saccharine matter in this milk arises from it's not being as it were masked by that of a great quantity of caseous matter.

Stipriaan's
experiments.

From the experiments of Stipriaan, the human milk was not coagulated by any of the acids, whether heat was used or not; nor was it coagulated by any of the alkalis, mild or caustic: soda of potash, however, by the means of heat, gave it a yellow, brown, red, and at last a black colour, which colours were weakened by the vitriolic acid.

Lime water, when boiled with it, produced a deep yellow colour.

The earths, neutral salts, &c. occasioned no change.

Infusion of oak bark formed a coagulum of a yellow colour.

Alcohol had no effect upon it.

Vitriol of copper, and the solutions of this metal in muriatic acid and vinegar, produced a blue colour; a solution of silver in nitrous acid gave it a dirty rose colour; and tin in the same acid a beautiful rose red.

The rennet of the lamb and calf did not coagulate it.

Sour coagulated milk when added to it produced a coagulum.

The electric fluid had no effect upon it.

The coal after evaporation afforded particles of iron.

The caseous part was coagulated by either letting it become sour and boiling it, or using old sour milk; this cheese was much finer, more tender, and softer than that of other milk; it, however, cannot be collected in a lump. Sixteen hundred parts of this milk afforded 137 Contents.
of cream, 48 of butter, 43 of cheese, and 117 of sugar;
300 parts of this last gave 85 of lactic acid.

Human milk becomes difficultly sour, it requires very Acetous,
often a fortnight and longer; sometimes when it has been vinous, and
kept a long time, it is insipid, and remains for months putrid fer-
without undergoing the acetous fermentation; from 300 mentations.
parts of the sugar, Stipriaan obtained 85 of the acid of
sugar of milk. He was unable to bring it to the vinous
or putrid fermentations.

It is, perhaps, owing to the great difficulty, if not impossibility of procuring this milk in a nearly similar state, which some authors have attributed to the irregularity of the human method of living, that the experiments of chemists differ so much respecting its coagulation; as there is no other milk which is so readily affected by the difference of nourishment. It is now asserted by Dr. Clarke, Clarke's
that it contains little or no caseous part. He attempted ideas on
its coagulation with all the different acids, alcohol, heat coagulation.
of various degrees, infusions of infants stomachs in various proportions, and assisted by different degrees of temperature, without the least success. He confirms in this respect the experiments of Ferris and Young, and states against Dr. Rutty, that if he had previously skimmed the milk, from which, by the means of rennet, he thought he had produced a little curd, he would have been unsuccessful. From his own experiments, which have been nu-

merous and of great variety, he concludes that the matter often vomited up by sucking infants, and which has been supposed to be coagulated milk, is not the caseous part, but a soft viscid matter, which he looks upon to be the cream. He was confirmed in this opinion, by observing that the human milk always threw up a copious yellow cream for some days after delivery, and having interrogated the nurses at the Lying-in Hospital on this subject, they informed him that the matter vomited up was yellow only during the *beasting period*, and that it afterward is white.

MILK OF THE ASS.

THIS milk is of a whitish colour, and according to Stipriaan, not so opaque as the other kinds. It has a peculiar odour and somewhat sweetish taste; accompanied with a slight saltiness.

It's specific gravity is as 1023 to 1000.

All the acids except the weakest, as the fluor acid, coagulate it.

Properties. Alkalis produce a very slight coagulation and various colours.

Neutral salts render it somewhat thinner.

Cream of tartar only coagulates it when warm.

Alcohol, rennet, solutions of lead, zinc, tin, iron, and copper in acids, coagulate it, and likewise produce more or less deep colours.

The coal after distillation afforded particles of iron.

This milk difficultly coagulates spontaneously, and the coagulum is not very consistent.

The *cream* is of a yellowish white colour, sweet sapid taste, and at first thin, but afterward thickened in consistence.

The whey is sweetish and of a yellowish colour.

The saccharine matter possesses a slight saline flavour. Sixteen hundred parts of this milk afford 47 of cream, 53 of cheese, and 72 of sugar of milk; 600 parts of this sugar gave 155 of acid.

It appears that although all acids and spirituous liquors coagulate this milk, it is in a different manner from that of the cow, for the caseous matter always separates in the form of extremely tenacious particles, which assemble at the bottom of the vessel, whilst the coagulum of the milk of the cow is in a mass, and occupies the whole of the fluid from which it is with difficulty detached.

This milk affords a *cream* that is never thick or abundant; it is with difficulty converted into butter, and this butter when extracted from it is always soft, of a white colour, and without any marked flavour. If care be not taken to separate this butter from the buttermilk as soon as it is formed, or if it be kept in a warmish place, it liquifies and mixes with the buttermilk, and cannot be separated again without plunging the vessel into cold water, and then using agitation.

According to the experiments of Parmentier, this buttermilk well deprived of its new cream has a very mild agreeable flavour, and the caseous matter is separated from it by acids, &c.

The *serum*, on evaporation, afforded a very white sugar, but not in the quantity expected from its sweet flavour; a little calcareous muriat was likewise found in the serum.

From the observations of Parmentier, it appears that asses milk is one of those which contains the least caseous matter; it adheres so little to the serum, that repose alone without any acidity is often sufficient to separate it; it then appears in the form of very fine particles. In this, it agrees with the human milk, which is suddenly converted into serum. In proportion as the caseous matter

manifests itself, the saccharine flavour becomes more evident, which effect cannot be attributed to the evaporation of the fluid, but to the evolution of the sugar.

The cream is never in abundance.

From the want of sufficient consistence in the butter, it cannot be had in a solid state during summer, and in winter it resembles a fluid oil. It's colour is of a dead white, whether in summer or winter, which gives rise to suspect that it contains a small portion of caseous matter, and the facility with which it grows rancid seems to confirm this opinion.

The salts contained in the serum, Parmentier found were not always the same; muriat of lime was the most general, but he has likewise obtained an admixture of muriat of soda. The first was of the cubic form, the other in a state of deliquescence, but the quantity of these two salts are very inconsiderable.

MILK OF THE GOAT.

GOAT's milk is very white, of a peculiar smell, and of a sweetish, somewhat fat flavour, which is very different from those already mentioned.

It's specific gravity is greater than that of the others; it is as 1036 to 1000.

With reagents, the changes in this milk are much the same as the last.

Cream.

To separate the *cream*, the milk must not be placed in too cool a place; the cream is exceedingly thick, of a mild and agreeable flavour, and when exposed to the air keeps a long time without suffering the acetous fermentation. From it's being so very thick, it is easily converted into a sort of cheese, which keeps well, and is very

rich. By agitation, butter is easily obtained; it is of a ^{Butter.} white colour, firm and solid in consistence, and in other respects resembles other butters.

The *buttermilk* abounds in caseous parts; sometimes it ^{Buttermilk.} contains more than the human and cow's milk. It is mild and agreeable to the taste, and its caseous matter may be separated by acids, spirit of wine, &c.

The quantity of curd is, from what has been said, very considerable, and is always in the form of a magma, so thick as to cause the separation of the serum with great difficulty. From the experiment of Parmentier and De-yeux, it appears that the abundance of caseous matter in ^{Abounds in caseous matter.} this milk is its principal character; in this respect, it is very different from human and ass's milk; it is to this circumstance that its great density is to be attributed, and the prodigious quantity of pellicles it affords on being heated. Another remarkable circumstance is the gelatinous state of this caseous matter on its separating from the serum, being very different from that of human or ass's milk, which never acquires any consistence, but appears in the form of extremely divided particles. Independent of these properties, this caseous matter of the milk of the goat, considered as an aliment, unites several others of great magnitude. Cheeses are made from it which are extremely rich, marrowy, and melting, and of a very agreeable taste.

As the cream is very thick, but never so yellow as that of the cow, the butter which is separated is always white; this, however, like that of the ass, does not depend on the interposition or combination of a certain quantity of caseous matter. Its consistence and manner of being acted upon by heat prove, that it does not depend on any foreign body for this property; besides, after having been kept a long time, if melted on the fire, it affords no deposit, as is the case when butter contains caseous mat-

ter amongst it's particles. It is most probably to this state of perfection, that this butter has the property of keeping fresh a much longer time than any other.

From Stipriaan's experiments, it appears that 1600 parts of this milk contain 127 of cream, 73 of butter, 146 of cheese, and 70 parts of the sugar of milk; one fourth of which is the lactic acid.

With respect to this last part, the saccharine matter, Parmentier's experiments prove, that in this milk it is not in proportion to the caseous matter; it contains even less than the human and ass's milk; it is always very white when the serum is spontaneously evaporated; if, however, artificial heat be used, the liquor at the term of crystallization remains sirupy, and it's consistence increases until it resembles a jelly. The crystals are also coloured, which is the reason why the sugar of this milk, which is made for commerce, is of a reddish colour. These inconveniencies are avoided by spontaneous evaporation.

Parmentier found this serum to contain a very small quantity of marine salt. It is the only foreign salt the presence of which is seen in the mother water remaining after the crystallization.

MILK OF THE SHEEP.

Resembles
that of the
cow.

In appearance, the milk of the sheep is very similar to that of the cow, and their physical qualities have a great resemblance.

It's specific gravity is to distilled water as 1035 to 1600.

It easily undergoes the acetous fermentation in summer.

Left to repose, it is soon covered over with a thick yellowish cream, pretty large in quantity, of a mild and agreeable flavour. This affords a good deal of butter, which never becomes of a very solid consistence. It's colour is of a pale yellow, and leaves an oily impression in the mouth. It easily becomes rancid, particularly if not well washed. The caseous matter, whether obtained by spontaneous or artificial means, always, according to Parmentier, preserves it's fat and viscous state, which prevents it's being easily collected; it's flavour is mild and agreeable. The serum when evaporated afforded a very white sugar. According to Stipriaan, 1600 parts of this milk afford 185 of cream, 93 of butter, 246 of cheese, and 67 of sugar, which gave one fourth of the lactic acid, and nearly as much from the fluid which remained. All the acids, and even the acid of fluor, coagulate it; fixed air has no effect upon it.

Soda and potash gave it a dark colour; if caustic, a red. Ammonia appears to make it thinner, and gives it a yellowish colour.

The neutral salts have no effect upon it.

It is also coagulated by alum, liver of sulphur when warm, and cream of tartar.

Although the difference between this milk and that of the cow is difficult to be ascertained by inspection, Parmentier found by analysis, that it's characters are sufficiently evident to prevent their being confounded together. This difference soon appears from the quantity of cream it furnishes; afterward the butter extracted from it presents to the chemist a still more marked difference, both with respect to it's consistence and taste. With respect to the caseous matter, the difference is still more striking, and affords a character which peculiarly belongs to it. It is remarkable for it's fatness and abundance.

From the richness of the butter, and the viscosity of the caseous matter of the milk of the sheep, it forms a part of certain kinds of cheese by mixing it with the milk of the goat; as in those of Roquefort, which, without this admixture, would be too dry and less delicate, the milk of the goat giving it whiteness. This is one of the most famous cheeses that France affords. As to the rest, the superiority which the milk of the sheep is known to possess in giving to cheese its richness, is recorded by this ancient proverb, *beurre de vache, caille de chevre, et fromage de brebis*. The muriat of soda found in this milk by the French chemists, has given rise to a suspicion of its proceeding from the salt which is given to them.

Roquefort.
cheese.

From the celebrity of the Roquefort cheese above mentioned, it will not be departing from considering it in a chemical point of view to give some account of its formation, and other properties.

Observations of
Chaptal
upon it.

We are informed by Chaptal, that the goats and the sheep, of the milk of which this cheese is formed, feed upon the Larzac, a large plain of ten leagues in diameter, very fertile and rich: he affirms that its quality seems to depend more particularly on the first operations in making. It often happens that cheese brought from different farms to Roquefort are of a very different nature, although from herds fed in the same manner. It is also frequently observed that cheese from the same farm, made by the same persons, and with equal care, are of different qualities. Chaptal is of opinion that these varieties of quality originate from the first operations it undergoes in its manufactory. He agrees in opinion with Huzard, in attributing the causes of the bad quality of cheese to the rennet. He thinks that its ever variable nature; the sojourning of the milk in the stomach of the calf; the variable quality of the curd; the more or less perfect mixture of the gastric juice with the food; the gastric juice

itself; and even the age, constitution, and temperament of the animal; all of them have more or less influence upon it. To obviate these faults, the rennet should be constant and invariable in its nature and virtue, this must be looked for amongst the acids. The manipulation has also great effect upon it. All the whey should be entirely pressed out, otherwise it becomes sour in a few days and spoils the cheese. The cheese when made should be dried in a fresh and dry air, and the month of May is the best season for this purpose. Delmas has found such cheese very superior to others; the fermentation having been thus prevented, and perfect dryness obtained. They are preserved in cellars of proper coldness, and with constant air.

The character of this cheese is mildness, whiteness, firmness, an agreeable taste, and colour marbled with blue. It, however, soon changes its quality from change of temperature and transportation; and so nice is its point of excellence, that it is agreed upon by connoisseurs, that it is only at Roquefort an exact idea can be formed of it. The first degrees of fermentation when in curd make it insensibly lose the insipid taste it has in that state, and at last it contracts a sharp disagreeable flavour; it is therefore between the extremes that the fermentation must be stopped. It is also necessary to attend to the changes after having been salted and placed in the cellars. It is first covered with a white down, which afterward becomes blue and then red. These colours arise from the attraction of oxygen, which by producing a different density, or otherwise changing the position of the particles, renders them proper to refract such and such rays, according to the refractive power of each. As the blue ray is the weakest, it is the first reflected when the oxygen gas is fixed in a body, producing the putrid fermentation. The red which succeeds the blue in this cheese is likewise a

natural consequence of the same principle; and in effect, it is proved according to Chaptal, that the red ray is that which has the strongest refrangibility, it is therefore that which is reflected when the concentration and combination of the oxygen gas is the strongest; this is seen in the calcination of most of the metals, and in the blood; but the nature of the principles with which the oxygen gas combines, and it's greater or less affinity with the different particles, modify the combinations and vary the results. It is from this red colour that they are able to judge of the perfection of the cheese.

MILK OF THE MARE.

It's properties.

THIS milk, like the rest, is white and opaque; it's smell is peculiar to the animal, which it retains in all it's parts, and it has a sweet and as it were an aqueous flavour.

It's specific gravity to distilled water is as 1045 to 1000.

The vitriolic, muriatic, and nitrous acids, coagulate it into thick lumps.

The phosphoric acid deprives it both of colour and opacity, so that it appears like water.

Acid of fluor has no effect upon it in the cold, but when warm slightly coagulates it; a similar effect is produced by the acid of sugar.

The alkalis render it more thin, and change it's colour.

Lime water has no effect in the cold, but precipitates the caseous part when warm.

Neutral salts render it thinner and clearer.

Highly rectified spirit of wine renders it equally curdy.

According to Stipriaan, an infusion of rennet has no effect upon it.

This milk is somewhat remarkable for it's fluidity ; it, however, is less so than the human, and that of the ass; but it is more insipid as to it's flavour. It's physical properties have great resemblance to other milks. Parmentier, however, observed that it easily boils, and is not difficult to coagulate. It's distilled water is nearly inodorous, and it gives a frangipane less unctuous and abundant than that of the cow. This milk scarcely feels the heat of the *bain mar.* before it is covered with pellicles less than those of the sheep ; and those which appear the first are the most unctuous, which is to be ascribed to the small quantity of cream it contains.

The serum, when the pellicles are taken away, is always very clear and colourless. With respect to the cream, it is pretty clear and of a yellowish colour ; it arises very soon after the milk is drawn from the animal. It affords no butter though agitated a long time ; it increases, however, in consistence, but affords no butter-milk, at least Parmentier was not able to procure any. The skimmed milk has the properties of that of the cow and goat ; it is, however, observed by the above chemist, that distilled vinegar and cream of tartar operated more difficultly the separation of the caseous matter, and when it appears some time after the mixture, it is in a form analogous to that of human milk treated in the same way. The serum by spontaneous evaporation was covered with a white crystallized salt in small needles, sometimes grouped, and sometimes isolated, and it likewise afforded a saline concretion ; the first was found to be sulphat of lime ; the other, sugar of milk ; and after two other crystallizations, the liquor remaining refused to crystallize ; it contained muriat of lime. Sixteen hundred parts of this milk, according to Stipriaan, afforded 13 only of

cream; 26 of cheefe, and 140 of fugar of milk; 100 parts of this last gave 30 of the lactic acid.

The experiments of Parmentier and Deyeux on this milk, were made upon some which had been taken from the animals two months after foaling; they found, that on fimple infpection, it was eafy to judge of it's ferous ftate, and they foon had a proof of it by the fmall quantity of cafeous matter it contained. They found, that diftilled vinegar would not coagulate it, as in the human; but it's cafeous matter was always made to appear of an extreme tenacity, when acids fomewhat concentrated were employed.

The greateft difficulty they found, was the feparation of the butter from the cream; and as Venel has obferved; from the fmall quantity of cafeous matter this milk contains, the nutritive property attributed to it muft depend lefs on the abundance of the principles which enter into it's compofition, than on the real manner in which they exift in it. With refpect to the fcrum, thefe two chemifts found, that the fugar obtained by the firft cryftallization was covered and mixed with a faline matter, which they took to be fulphat of lime; and this is the only milk which afforded them a falt of this kind.

Contains
fulphat of
lime.

Since this milk appears to have been the firft from which an ardent fpirit was obtained, it may be thought neceffary to give fome account of it.

An ardent
fpirit firft
obtained
from it.

It has been obferved by travellers, that the different hordes of Tartars have for many ages been accuftomed not only to prepare an agreeable acefcant liquor from the milk of the mare, to which they give the name of kumifs, but that they are able to extract by diftillation a very ftrong fpirit from it. The method, however, in which this was done remained unknown; and we are informed by Grieve, that when he was in Ruffia, it was with great difficulty he obtained the method of making it. He

has given the following account of the method usually practised in the preparation of kumifs by the Beshkir Tartars. Take any quantity of fresh mare's milk, add to it one sixth part of water, and pour the mixture into a wooden vessel. Use then as a ferment one-eighth of the fourest cow's milk, but a small portion of old kumifs is best; cover the vessel with a thick cloth, and place it in a moderate temperature; when on reposing twenty-four hours, a thick substance will be collected on the surface, which is to be beaten with a stick until it is intimately mixed with the fluid part. After reposing another twenty-four hours it is put into a narrow vessel, and stirred until it is perfectly homogeneous; in this state it is called kumifs, and has an agreeable taste, which is a compound of sweet and sour. It is stirred every time it is used. Grieve was told, that if this be put into close vessels, in a cool place, it will keep three months or more.

We are informed, likewise, by Eaton, who was many years resident both in Turkey and Russia, that the Arabians and Turks have a preparation similar to the *kumifs* of the Tartars; by the first it is called *leban*, by the Turks *yaourt*. It is made by putting some of the old sort to new milk made hot over the fire, when in a few days, more or less, according to the temperature of the atmosphere, it becomes coagulated into an uniform consistence, and of a most pleasant acidulous flavour; the cream is in great part separated, leaving the curd light and semitransparent; and the whey is much less subject to separate than by our method of using rennet for the purpose of cheese making.

"Yaourt," says Eden, "has this singular quality, that left to stand it becomes daily more sour, and at last dries, without entering the putrid fermentation. In this state it is preserved in bags, and in appearance resembles pressed curds after having been broken by the hands; and

this dried yaourt; when mixed with water, becomes a fine cooling drink, or food." Fresh yaourt is an article of food amongst the natives, and it appears that Europeans soon become fond of it. The same gentleman informs us, that no other acid will make the same kind of curd, for after the acetous fermentation is over, the whole becomes putrid; that in Russia they put their milk in pots into an oven, and let it stand until it becomes sour, and this they use as an article of food, or make it into cheese; but it has none of the qualities of yaourt, though when new resembles it in taste.

This yaourt or leban is so valuable an article with the people, and is looked upon with such high consideration, as to give rise to a story of their first having received it from the hand of an angel, who taught Abraham how to make it, and that the angel brought a pot of it to Hagar.

With respect to the knowledge the Tartars had of extracting a spirit from this kumiss, we are informed by Marcus Paulus, that it was known to them even in the thirteenth century; to this spirit they gave the name of arki or ariki. We are informed by Pallas, that when they are in want of mare's milk they use that of the cow; but they prefer the kumiss, from it's containing a greater quantity of spirit, viz. one third of the whole; whilst the milk of the cow only affords two ninths. The Kalmuc Tartars call that from the mare tschigan, and that from the cow arjan or airer. This report of Pallas is confirmed by Beretshonshys, who accompanied Lepechin and some other academicians in their travels into Siberia and Tartary, and who published in 1778, at Strasburg, a dissertation on the ardent spirit to be obtained from milk. As authors have differed respecting the absence or presence of some of the component parts of milk in making this spirit, Oseretzkowsky made some experi-

ments on this subject, and found that the milk must not be deprived of any of it's parts ; he found, that the milk when deprived of it's butter gave no spirit, neither of itself, nor by the addition of a fermenting substance ; that imperfectly deprived of it, and likewise of most of it's caseous matter, the whey afforded very little spirit after the acetous fermentation ; and, on the contrary, milk that had been fermented by constant agitation in a close vessel, without any alteration of it's parts, produced the most spirit ; and that a still larger proportion was obtained, if the fermented milk was not immediately distilled, but left to stand some time, as it became much milder respecting it's acid. He took six pounds of cow's milk, put it into a glass with a narrow mouth, let it remain in it two months, shaking it well two or three times a day. During the agitation a great quantity of an aerial gas was extricated, and on the surface there was a white mass collected, full of air bladders, which disappeared on shaking ; at length, the cream united again, with the caseous parts and whey, and perfectly resembled fresh drawn milk in colour. There being no more air, the odour was very sour, and the liquor not unpleasant, but strongly acetous and somewhat vinous to the taste. He then let this lacteal wine stand a fortnight longer, in a well closed bottle, when he found it was become much milder, and approached the lacteal spirit in taste. By repeated distillation he obtained three ounces of a very strong spirit, which, on inflammation, lost one half. It is now found that all milks contain more or less of this spirit ; and it was remarked by Macquer, long ago, that the human milk on standing acquires in a short time a vinous smell which is not unpleasant ; and Voltelen has found, that on distillation, the human milk affords a much greater quantity of a gaseous fluid than any other milk.

General re-
fections.

From the analysis and physical properties of the different sorts of milk, it appears, that their odour, flavour, and consistence, are such nice distinguishing characters, as to make it very difficult to lay hold of them, unless by a further comparison. They all possess volatile principles, the nature of which we are ignorant of; for neither the odoriferous particles, nor those which give them flavour, have been obtained, unless in combination with water. From the difference, however, of their striking the organs of sense, we may conclude, that they must necessarily differ amongst themselves. They all afford *cream*; but this, which is thick in the milk of the cow, is still more so in the goat's and sheep's; whilst in human, ass's, and mare's milk, Parmentier always found it less abundant and more fluid, which make them approach nearer to each other, preserving, however, shades by which they may be distinguished.

In the various kinds of *butter* the differences are still more marked than in the cream; that of the cow, for instance, separates more easily, and once separated, is no longer miscible either with milk or water; in consistence it is generally pretty firm; the butter of the goat separates with the same facility and agrees with it in consistence, but it is constantly more insipid in taste; whilst the butter of the sheep, although abundant, remains soft in all weather. As to the three other milks, although Parmentier was not able to extract the butter, he has no doubt of its existence.

With respect to the *caseous matter*, it differs still more; that of the cow first appears in a gelatinous form, being as yet impregnated with the whey in which it was formed; when separated, it becomes in some measure fibrous. The curd of the goat has nearly the same properties; whilst that of the sheep is always of a viscous consistence. In the human milk, the caseous matter

never separates spontaneously in a homogeneous mass; it is always in a divided state, preserving after it is collected a sort of creamy unctuousity. That of the ass has indeed a gelatinous appearance, but deprived of it's whey it loses it in some measure; whilst the curd of the mare resembles it by forming in a mass, but with greater difficulty.

It appears, therefore, a general rule may be established, viz. that every species of milk incapable of furnishing caseous matter under a gelatinous form by ordinary means, will never afford butter to be compared to that of milk, the coagulum of which is well characterised; as is evident from the human, ass's, and mare's milks, which coagulate ill, and afford butter with difficulty; whilst those of the cow, goat, and sheep, which coagulate well, always produce firm butter, and with the greatest facility.

With respect to the *serum* of these different milks, it varies as to quantity and flavour, and may be obtained clear and colourless when no recourse is had to fermentation or the fire. It is afforded in large quantity by the ass's, mare's, and human milks, whilst the goat's and cow's give less, and the sheep's least of all.

It appears, from Parmentier's experiments, that of all the essential parts which constitute the different milks, the saccharine part was the only one in which no difference could be observed; it had the same flavour and colour in all, and may be properly denominated the *essential salt of milk*.

With respect to the milk of animals under disease, although it is constantly undergoing changes in health, these changes are infinitely more sensible when they are ill; but it appears, the most curious circumstance is, that the alteration principally takes place in the caseous part, which is the only part in milk that is really animalized;

and it appears further that what happens to milk, takes place equally in all animal fluids ; thus in the blood, the bile, and the urine of an animal under disease, it is always the lymphatic part that undergoes a species of decomposition ; whilst the serous and saline parts suffer no change. Parmentier observed, that the change in the caseous part of milk varied according to the species of the disease.

From the experiments of Stipriaan on the above milks, we have the following observations : he found the milk of the ass to be the most *aqueous* ; then followed that of the mare, the human, the cow's, the goat's, and least of all was that of the sheep.

With respect to *cream*, the sheep's afforded the most ; then the human, the goat's, the cow's, and the ass's and mare's gave the least quantity.

Of *butter*, the sheep's produced the largest quantity ; then the goat's, the cow's, and the human milk.

Of *cheese*, the sheep's had the preference ; then the goat's, the cow's, ass's, and the human milk, whilst the mare's gave the least quantity.

The most *sugar* was extracted from the milk of the mare ; then followed the human, the ass's, and the goat's, the sheep's gave less, and the cow's least of all.

Such are the observations of chemists on the milks of various animals ; from the analysis of which, Parmentier has divided them into *two classes* ; *the one class* comprehends those milks which abound in serous and saline parts, as that of the ass, the mare's, and the human ; *the other*, those which are rich in caseous and butyraceous parts, as those of the cow, the goat, and the sheep ; “ in short,” says that experienced chemist, “ it marks the species which is to be preferred, in such and such circumstances, in order to pass from one kind to another, and even successively from the use of one milk to another, without being exposed to any inconveniency.”

Whatever may have been the different opinions of authors with respect to the means of perfecting the butyraceous and caseous parts of milk ; there is no doubt but that the means of increasing it's quantity, and of making it excel in quality, is to nourish the animals well from which it is drawn ; by keeping them clean ; often renewing their litter ; milking them at regular periods ; and procuring for them the best food. The experiments of Parmentier have, likewise, proved to him, that milk always participates of the individual from which it is drawn, as well as of the aliments which have served for it's nourishment. It has long been observed, that plants communicate to the milk their particular flavour and odour ; thus, bitter plants are said to give it their bitterness ; the garlic it's strong and disagreeable taste ; that colour is given to it by some plants, as the saffron ; and their purgative quality by others ; that Indian corn gives it a sweet flavour ; and the more aqueous plants render it aqueous and insipid. It is, however, very well known, that all plants do not contain sugar in the same quantity, whilst many do not contain it at all ; which seems to prove, that from it's constancy in the milk of animals, the animal system, as well as vegetable, has the property of producing it. “ But if the flavour of the milk,” says Parmentier, “ (independently of the peculiar nature of the animal), be owing to the reunion of the different principles that constitute this fluid ; it is not less true, that these principles receive, on the part of vegetables, characters which are in some sort indelible. If plants contain, for example, mucous matter in abundance, the milk will give a great deal of caseous matter, and it's flavour will be insipid or sweet. If, on the contrary, they are very aromatic, the butter will be sapid, from the affinity of the *esprit recteur* with the oily matter. In the same manner the milk will be coloured, if the plants contain a colour-

ing matter, soluble in one of the principles ; and it will abound in whey or serum, if the plants contain much humidity. In short, all the products will be more fine, more solid, and more perfect, according to the tenuity of the oily, mucilaginous substances, and to the coriaceous, hard, and fibrous state of the plants, which concur to their formation. This being admitted, it is easy to see, why the most perfect butter, and the most esteemed cheeses, are made from milk of cattle nourished in meadows where many odoriferous plants grow ; and when these meadows have lost, by exsiccation, their perfume, and their superabundant humidity, they give a less delicate and more firm butter ; whilst cows, furnished simply with the stalk and leaves of the maize, give always a sweet milk, an insipid and firm butter, on account of the insolubility of the saccharine body in the butter, of the absence of the aromatic part, and of the solidity of the vegetable. It will further explain, why the milk of the cow fed by potatoe tops, which are more aqueous than maize, gives equally an insipid butter, but of a less firm consistence ; why the cruciform plants communicate a strong taste to butter, whilst the whey is almost insipid ; in short, why cows, that feed in moist places, give milk less rich than those feeding on high and open pastures. If, therefore, we wish to make the butter and cheese of cows fed in the first pasture more perfect, some aromatic plants must be added to their common food ; whilst succulent and inodorous plants must be added to those nourished in the second ; for good pastures depend as much on the soil and aspect as on the variety of plants of which they are composed. To conclude ; the foundation of the opinion of those authors, who say, that manipulation does every thing respecting the quality and the quantity of butter and cheese, and the pastures nothing, is totally overthrown by reason and experience ; for the influence

of vegetables on the nature and quantity of these two products are evident, as well as that of the processes employed to facilitate them."

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GASTRIC JUICE.

A men-
struum of a
peculiar
kind.

THE gastric juice, when pure and in a healthy state, is a thin, transparent, unflammable fluid, secreted into the stomachs of animals by certain glands or vessels, situate in the coats of that viscus, and forming a menstruum of a peculiar kind, for the digestion of the various aliments.

Neither acid
nor alkali-
ne.

Action of
regents
upon it.

It has no smell, is of a weak saline taste, and colourless as water. It is neither acid nor alkaline, consequently does not change the colour of litmus or of violets. It unites perfectly with water. When mixed with alcohol, an animal portion of it is precipitated in the form of a coagulum, in small quantity; by Plenck said to be of an albuminous nature, by others to be gelatinous.

Does not
become
putrid.

Curdles
milk.

It neither effervesces with acids nor with alkalis, nor is coagulated by them. It is more difficultly frozen than water. It undergoes neither the acetous nor putrid fermentation.

It curdles the caseous part of milk. It dissolves vegetable or animal matter, or both, according to the nourishment of the animal. From the experiments of Carminati, it dissolves iron, crude antimony, the flowers of zinc, and corrosive sublimate; but has no effect on copper, cinnabar, or sulphur. It is highly antiseptic.

Distilled.

It is easily evaporated, and by a gentle distillation in a water bath, it affords nothing but water, which is neither acid nor alkaline; the remainder is of an animal nature, containing a little muriat of soda; hence, the gastric juice when pure, and taken from the human body in a state of health, is composed of water, muriat of soda, and an animal substance, which, according to

some, affords phosphat of *ammonia*. In the state in which it is generally found in the stomachs of animals, it varies more or less in its properties, not only in the same animal at different times, but in those whose organs of digestion are different in their structure, and in these the variety is still greater. Much likewise depends on the nourishment, powers of digestion, and other circumstances difficult to explain. Thus, it may be generally laid down as a rule, that the gastric juice in the *carnivorous* and *graminivorous* classes of animals, which have only one stomach, is acid, and colours the syrup of violets red.

When impure is found in some animals acid.

In the *omnivorous*, such as man, whose food is composed both of vegetable and animal diet, it is neutral.

In others neutral.

In the *graminivorous* ruminating animals with four stomachs, and particularly in the adults, it soon becomes putrid, and colours the syrup of violets green.

In others alkaline.

It appears, however, from the experiments which have been made on the different gastric juices, that they have all of them three properties in common, viz. they dissolve vegetable and animal substances with more or less facility; coagulate the caseous part of milk; and possess an antiseptic quality.

A more minute examination of the properties of the different gastric juices has been made by Carminati, Brugnatelli, and Macquart.

According to Carminati, the gastric juice of the *carnivorous* class of birds, such as falcons, hawks, herons, and owls, differ both in density and colour; it has, however, in all, a bitter saline taste, is evidently acid, and examined by the moist way, besides water, contains a dark coloured very bitter resinous matter, with a penetrating and peculiar odour; an animal substance of the same colour, very little ammoniacal, and a greater quantity of marine salt. In the dry way, the products of dis-

Experiments on the gastric juice of the carnivorous class.

tillation were much water, an acid, a few drops of an acrid, fat oil, adhering to the neck of the receiver, with a saline substance affording the smell of ammonia. The caput mortuum gave crystals of marine salt, and the incinerated ashes a little iron and some calcareous earth.

The experiments of Brugnatelli on the gastric juice of the owl agree pretty much with those of Carminati; he found it to be less aqueous than that of animals which feed on vegetables, of a dark colour, turbid, and a sharp bitter taste, and a penetrating, acid, rancid smell; he found it contained likewise a resinous matter, a free acid, and a little common salt united to an animal matter; it is very antiseptic. Carminati found the gastric juice of graminivorous nonruminating animals, as the rabbit, &c. to have the same properties, and to be similar in it's contents to that of the carnivorous.

Omnivorous class.

With respect to the *omnivorous* class, such as man, cats, dogs, crows, &c. he observed that their gastric juice was neutral when nourished with flesh and vegetables; but if only with flesh, it became perfectly similar to the carnivorous gastric juice; on distillation, he obtained a water that sometimes became alkaline, owing as he thought to it's being impure, for when fresh the water was insipid; the rest was a phlegm, a little black and acid oil, and the caput mortuum resembled that of the preceding class.

Brugnatelli found an acid in all animals of that class, or in cats and blackbirds, &c. and having fed them with flesh a few days, it resembled that of the owl. He kept an owl for ten days on vegetables; it, however, did not lose it's acid, but only became more aqueous. He attributes it to it's drinking water, which is not the case when fed on flesh. He found the gastric juice acid in the graminivorous fowls, such as pigeons, quails, ducks, hens, &c.

Scopoli triturated some gastric juice of the cow with caustic potash and quick lime, and he distinctly perceived an urinous and acid odour. It sensibly changed violet sirup green; poured into a nitrous solution of silver, it afforded a precipitate that resembled the muriat of silver. Two drachms slowly evaporated, left two grains of a grey matter, which had a disagreeable odour, deliquesced in the air, and did not effervesce with acids. On distillation, it afforded an empyreumatic phlegm, whilst a white matter was attached to the side of the retort, which, when triturated with lime, manifested an urinous odour; the residuum had the consistence of an extract, had an empyreumatic smell, saline taste, bitter and nauseous; it neither effervesced with acids nor alkalis, and put into a solution of potash, there arose a very penetrating odour of volatile alkali. He concludes that pure gastric juice is composed of a saponaceous and gelatinous animal substance, of sal ammoniac, and of an earth similar to that which all animal fluids afford. "Since it is evident," says Morveau, "that this chemist has only judged of the nature of the acid by the appearance of the saline precipitate of silver, much is wanting to make the proof sufficient, since other acids likewise precipitate this metal. These doubts are the more admissible, since the author carries the consequences of these results to a greater length; he goes so far as even to suspect that the muriatic acid is *the product of the vital power* in animals; he looks on the fact as proved, if the gastric juice of animals nourished with vegetables likewise affords sal ammoniac; and Spallanzani assures us, that after having fed five crows for fifteen days solely on vegetables, he found the gastric juice to afford likewise a precipitate of luna cornea." Other experiments are necessary, and better proofs required before so new a system can be received, or before the nature of the

acid can be determined, which, in the gastric juice, puts the ammonia into the state of a neutral ammoniacal salt.

Graminivorous
class.

The *graminivorous* ruminating class, according to Carminati, is composed of similar principles to the preceding, if a portion of ammoniacal salt be excepted in the gastric juice, which he believes to be in reality acid. He has, however, found the gastric juice of lambs, sheep, goats, and herbivorous calves, taken a long time from the living or dead animal, very often alkaline so as to effervesce with acids; but the alkali he looks upon as the product of the putrefaction of the herbs, which sojourn a long time in the stomachs of these animals; he founds his opinion on the following observations: 1st. the gastric juice of these animals is often found acid. 2d. it is always so in sucking calves, and even in the ox, after having fasted some time, or rather after a good and perfect digestion. 3d. fresh grass digested in pure or salt water, at a heat between twenty-five and thirty of Reaumur, becomes alkaline in a few days. 4th. similar grass being plunged in the gastric juice of ruminating animals, whether acid or alkaline, the acid juice became alkaline in the space of four days; and 5thly, the gastric juice of sheep, which had fasted a long time, was found acid. On distillation, the gastric juice of this class at first afforded an alkaline, and afterward an acid water; when, on concentrating this water, he collected a little acid from it which he looks upon as an animal acid. It likewise afforded some ammoniacal salt, which, however, is not always the case, and an empyreumatic oil; the rest was similar to the preceding.

According to Brugnatelli, the gastric juice of this class, such as the sheep, &c. is found in all the four stomachs, but the purest in the first: it is very aqueous, in opposition to that of the carnivorous class, a little turbid, and of

a pale earthy colour : it consists of a great watery portion of volatile alkali, of an animal extractive matter, with a good deal of sea salt : it is bitter, sharp, and saline to the taste : it easily putrifies in summer, and in four or five days smells like rotten eggs.

Macquart has likewise made some experiments on the gastric juice of the ox, the sheep, and the calf. The juice from the stomach of the ox he collected when fasting ; it smelled like straw, to which was sometimes added a resemblance to musk ; each animal afforded one pound and half, which he filtered and preserved in bottles for use, but it was impossible to procure it clear and transparent. He found on analysis,

1st. That one pound four ounces gave ten grains of a lymphatic matter, having the same properties as that of blood.

2d. $16\frac{6}{7}$ of phosphoric acid.

3d. 5 grains of phosphat of lime.

4th. 2 ditto of resin.

5th. 14 ditto of sal ammoniac.

6th. 29 ditto of muriat of soda.

7th. And a small quantity of extract remained difficult to appreciate.

8th. The quantity of water was one pound, three ounces, six drachms, and 67 grains and half.

Total 1 lb. 4 ounces.

The stomach of the sheep contains from five to eight ounces of pure viscous gastric juice, of a deep green colour, and more disposed to putrefaction than that of the ox or calf ; from this he separated the lymph by means of heat ; he found that volatile alkali discovered the presence of the phosphat of lime ; that spirit of wine rendered the sal ammoniac and resin sensible ; that lime, by

the weight of the precipitate it affords, indicates that of the disengaged phosphoric acid; and lastly, his analysis procured the presence of marine salt. One pound of this gastric juice afforded

| | |
|---------------------|------------|
| Lymph | 64 grains. |
| Phosphat of lime .. | 10 |
| Muriat of ammonia | 13.20 |
| Resin | 10 |
| Phosphoric acid .. | 10 |
| Marine salt | 13.18 |
| Extract | 2 |
| Water | 153 33 62 |
| <hr/> | |
| Total | 1lb. |

Hence, according to Macquart, the gastric juices of the ox and sheep are of the same nature; but the last contains more serum and extract, and is more liable to the putrid fermentation in consequence.

The stomach of the calf Macquart found to contain from four to six ounces of gastric juice, always mixed with a reddish grey matter with much hair. When filtrated it has a light grey colour, precipitates lime water, and affords a white deposit by the addition of volatile alkali. It begins to ferment in five or six days exposed to a temperature of 20° of Reaumur. It then deposits a white powder of a disagreeable smell. It contained phosphat of lime and sulphat of lime; exposed to a boiling heat, it deposits but very little coagulated lymphatic matter. One pound of this gastric juice afforded

| | |
|-----------------------|----------|
| Lymph .. | 4 grains |
| Dry jelly | 24 |
| Selenite | 6 |
| Phosphat of lime | 10 |
| Sal ammoniac | 12 |

Lactic acid 48 grains.

Marine salt 40

Phosphoric acid 4

without reckoning the sugar and the extract contained in the juice. Hence it appears that the gastric juice of the calf differs from both the preceding, by containing a greater quantity of gelatinous matter, sugar, and selenite. The difference is greater from the lactic acid it contains, which is in great abundance. Macquart found, that the proportion of the principles in the gastric juices of animals varies from their individual strength, their age, and more especially from the nature of the climate, in which he agrees with other chemists; and he has determined that the gastric juice of ruminating animals contains the phosphoric acid, and not one *sui generis*, and in this he has been supported by Struve.

OF THE ACIDITY OF THE GASTRIC JUICE.

THE property which rennet has of coagulating the caseous part of milk was known in the time of Dioscorides; and as it has been remarked that acids had the same effect, it was natural to suppose they would attribute this property in rennet to its possessing an acid. Many celebrated writers have likewise remarked, that the gastric juice of carnivorous animals is acid. Thus Floyer found it acid in carnivorous birds; Marfigli, in the eagle; Viridet, in carnivorous fish; and Lorenzini in the cramp-fish; but all have attributed this acidity to the unnatural state of the gastric juice. With respect to rennet, which is the dried stomach of the calf; it is the fourth stomach of the ruminating tribe only that possesses this quality.

Acidity of
the gastric
juice.

The juice found in the craws of birds has not this property. Macquer looked upon it's coagulating property to arise from the remnant of sour milky matter, which he thought was sufficient to coagulate the milk. It is, however, now proved that this property arises from the nature of the gastric juice itself; that this virtue is communicated even to the coat of the stomach itself, and to a certain point to the neighbouring parts which are most impregnated with it. It therefore remains to examine whether this property arises from the gastric juice being an acid, or from it's own peculiar nature. Morveau digested at different times parts of the interior tunic of the stomach of the calf, both in hot and cold water, previously distilled; he then poured some spirit of wine upon it, which occasioned a precipitate, and he always found that the filtrated liquor sensibly changed blue water to a red. According to Scopoli, the human gastric juice is sometimes acid, and at other times not; which is proved by the acid or insipid eructations, either when fasting, or during the time of digestion. The gastric juice therefore, being found so very generally in a state of acidity, Morveau has placed it in the French Encyclopédie amongst the animal acids, under the name of the *gastric acid*, doubting at the same time whether it be an essential part of it's nature. From the experiments of Spallanzani, this acid quality depends on the aliments; for birds of prey never gave the least sign of any acidity; and the same may be said of frogs, serpents, and fish. He found that when the gastric juice of crows afforded him signs of acidity, they had been nourished on vegetables; and the same observation might be applied to dogs, graminivorous animals, and the gallinaceous class. Shells and coral were likewise rendered up by carnivorous birds, without having undergone the least alteration, which would not have been the case if the juice had contained an acid. Spallanzani likewise swallowed calca-

reous substances enclosed in tubes, which he found were only diminished when he used vegetable food or fruits; and that when he fed on animal food they were always untouched. The testimony of Goffe of Geneva may likewise be adduced, for he was not able to sustain any length of time the use of crude vegetables, from the frequency of the acid eructations they occasioned. In short, Monck, after having observed that calcined magnesia was not in any way soluble in the gastric juices of different animals, affirms, that he has seen the gastric juice vomited by a hypocondriac person to be acid, effervesce strongly with crabs eyes, and dissolve two grains of calcined magnesia.

Spallanzani is of opinion, that in it's natural state the gastric juice is neither acid nor alkaline, but neutral. His reason for thinking so is, that the acid which is manifest at the beginning of digestion in the stomach of some animals, constantly disappears toward the end of that process, and is very inconsiderable; and that when gastric juices are poured into a solution of the carbonat of potash, there never arises any effervescence; which proves that they either contain no disengaged acid, or that the acid is not sufficiently powerful to displace the carbonic acid.

The difference in the result of the experiments of those who have investigated this liquor, it is evident, must have arisen from the difficulty of procuring it in a pure and healthy state, for it would appear that the acidity is owing entirely to the food. It is well known that vegetables, when exposed to a heat equal to that of the stomach, are very prone to the acetous fermentation; and that on the contrary, animal food under the same circumstances tends to the production of volatile alkali; and these will take place in proportion to the weakness of the stomach; or if the quantity of food taken exceeds the power of the gastric juice to prevent them; for it is prov-

ed from experiment, that this juice when pure is much disposed to counteract either, and in weak stomachs, such as children, the contents are often sour, as is easily known from the acid eructations and the use of magnesia. Likewise, that food in carnivorous animals, when taken in too great quantity, is very apt to tend toward the putrid fermentation, is evident from the putrid eructations, and the disagreeable smell of dogs and other animals of that class, which are apt to eat voraciously. It would seem, therefore, that both the acid and the alkali, when found in a separate state in the gastric juice, proceed from these causes; and the same thing happens in vegeto-carnivorous animals, where the neutral salts are found. To these it may be added, that it's not being always found to have acid properties, is a proof that they are only accidental, and like the alkaline, only proceed from foreign causes; and that when found in a neutral state, it does not appear to alter it's properties as an animal and vegetable menstruum, which would be the case if it's powers depended on it's acidity. But the experiments of Fordyce and Hunter, appear to put the matter out of all doubt. Dr. Fordyce found, that when dogs had bread for their food, which is not their natural aliment, in about four hours after, an acid was discovered on examining that part which had passed into the beginning of the duodenum; but on changing the food for meat, no acid ensued. The same with respect to sheep and cows, the natural food of which is vegetable; for the matter at the beginning of the duodenum in these animals showed not the least trace of acidity, as it neither changed the colour of red cherry juice, nor litmus, which are the most delicate tests. Hunter, about the same time, found no acid in the previous or digestive stomach of rabbits, and other animals of the same kind.

Dr. Fordyce even found, that when the stomach was in perfect health and vigour, if putrid meat was conveyed

into it, as being swallowed by a dog, it was rendered perfectly sweet again. The inhabitants about the mouth of the Orange river, in Africa, live always on animal food, which is often putrid, yet they are strong and healthy; and maggots that live upon and in putrid masses, are themselves perfectly sweet, and their fluids are entirely free from the least taint of putrefaction.

METHODS OF PROCURING IT IN IT'S PURE STATE.

SINCE many errors may have arisen from the difficulty of procuring the gastric juice in a pure state, from it's being easily affected by acid or rancid substances taken into the stomach, or from it's admixture with the bile from the duodenum, many methods have been invented to procure it in a state proper for experiments; three of which I shall describe as being the least liable to mislead the chemist.

The *first* and most simple method is to take it after the death of the animal; and if previous to this, it be suffered to fast for some time, it will not only be obtained in greater abundance, but the danger of any admixture of the aliments will be decreased. It was in this manner that Spallanzani obtained 37 ounces of gastric juice from the two first stomachs of a sheep, after it's fasting two days; it was of a green colour, which might proceed from a small quantity of grass remaining there, and which is a proof how difficult it is to procure it perfectly free from other substances. He likewise opened some young crows that had not flown, and found about half a spoonful, which was more than he could get from adults. This method, however, is very cruel, and will scarcely be attempted by the more humane philosopher, whilst he has other means in his power.

A *second* method is by means of sponges. Reaumur 2d. method.

made use of them without any defence, but Spallanzani placed them in little thin metallic tubes, pierced with small holes; these he made the animals swallow. He obliged some crows to take each eight of these tubes, successively, when, in the space of three hours and a half, they were vomited up again. He collected from five crows 481 grains of gastric juice, of a yellow, transparent, dirty colour, saline and bitter to the taste, affording very little sediment if the bird had fasted, and which although exposed to the air for several hours, evaporated very little, and extinguished flame. This yellow colour and bitter taste most probably arose from the bile, as well as the resinous matter which is found in the gastric juice.

3d. method. A *third* method is to procure it in the morning, fasting, by exciting vomiting; in this manner, Spallanzani procured it twice, by irritating his throat with his two forefingers. At one time he got by this means one ounce thirty-two grains of a viscous, foamy liquor, which, after having deposited a slight sediment, became as limpid as water; it was without colour, of a saline taste, without any bitterness, unflammable, easily evaporated on the coals in an open vessel, but in a close one kept during a month in a very hot Italian summer, without either change of taste or odour; the pain, however, which he suffered from the irritation, prevented him from trying the experiment a third time; and Scopoli has remarked, that by this means only, the more fluid parts are obtained, as the thicker portion remains attached to the bottom of the stomach, and is only to be procured by the more powerful emetics, such as tartar emetic, &c. A more easy and profitable way of exciting vomiting, is that pursued by Goffe. This estimable philosopher has the power of rendering the contents of his stomach by swallowing air, which acts as an emetic; by which means he can procure the gastric juice in a much purer state than by dissections. To this it may be added, that Spallanzani has

remarked, that the eagle renders a considerable quantity of gastric juice spontaneously, in a morning when fasting, exempt from foreign matter, of an ash colour, nearly as fluid as water; it is saline, bitter, uninflamable, and has the same odour as other gastric fluids; he procured about six drachms of it every day, by placing a glass vessel before the bird. Such are the principal methods by which this fluid may be obtained in as pure a state as it's nature and situation will admit of; but there is reason to believe, that the mucus and saliva which are constantly mixing with it in the stomach may alter it's properties, whilst the bile may be the cause of it's resinous bitter taste and yellow colour, which it is sometimes known to possess.

Besides the methods just related of procuring this fluid for the sake of experiments out of the body, others have been invented by which different experiments have been made on the powers of this fluid, whilst it remains in the stomach, by which it's action on different substances may be better known, perhaps, than in any other situation, and when extracted from it's natural viscus. This was first introduced by Reaumur, who forced sheep to swallow small tubes of metal filled with grass and other herbs. It was followed by Spallanzani, who has employed the same method on a great number of different animals. The tubes were filled with the food peculiar to the animal, or with other substances, and were examined either on being rendered by the anus, or by exciting vomiting after a given time, or by opening the animal; whilst some of the birds vomited them spontaneously in a few hours after having taken them. Spallanzani and Goffe tried these methods on themselves; The first began by swallowing small purses of roasted or raw flesh, or filled with bread, &c. Afterward he took small cylinders of wood, pierced with holes, and covered over with linen;

Experiments upon the gastric juice in the stomach.

but with respect to Gossé, from the facility of rendering them at pleasure, he was able to swallow different substances, to keep them as long in his stomach as he thought necessary, then restore them up again to observe and compare the progress of digestion; and he has made so many experiments on vegetable and animal matters, as to be able to form them into different classes, viz. Those substances which appeared to him indigestible; those in part digested; those of easy digestion; those which hastened digestion; and those which prevented or diminished it.

It is supposed also by Brugnatelli, that the white matter which is generally found in large quantity in the excrements of carnivorous birds, and which differs very much in consistence, which is soluble in water, and gives a straw coloured liquor, is a portion of gastric juice, and may be of use in experiments. Such are the methods employed in experiments on the gastric fluid.

ANTISEPTIC QUALITY OF GASTRIC JUICE.

It's antiseptic quality.

It has been observed that the gastric juice possesses an antiseptic quality, by which it not only preserves itself from putrefaction, but substances which are put into it. Various experiments on this power of the juice has been made, amongst which the principal are those by Jurine, Carminati, and Spallanzani. We are informed by Carminati, that the gastric juice of *carnivorous animals* was placed in vessels exposed to the air and heat of different seasons; and that it always kept good and free from putridity until it became perfectly exsiccated. That when

In carnivorous animals.

this gastric juice was mixed with blood, or poured in different quantities on fresh and corrupt meats; it afforded various proofs of it's antiseptic quality, either by preserving them from corruption, or in correcting it after it had taken place; and it's action is the more certain and sudden, the greater the quantity of the gastric juice employed, relative to the substance to which it is added.

Spallanzani has likewise proved the antiseptic power of the gastric juice. He found that to produce artificial digestion, little or no solution takes place, unless the gastric fluid employed be exposed to a brisk heat, but this heat is not necessary for it to retain it's antiseptic powers. He found that the gastric juice of the crow and dog preserved veal and mutton 37 days in winter, without it's being either consumed or putrid; whilst the same meats immersed in water emitted a fetid smell on the 7th, and about the 30th day were changed into a very offensive liquamen. Yet the gastric juice loses at last it's antiseptic quality, even though kept in phials perfectly well stopped, but it never becomes putrid itself. He found that flesh which had an insupportable stench when put into the gastric fluids of the dog, crow, owl and eagle, during the month of March, at a temperature of from eight to twelve of Reaumur, kept twenty five days, and was somewhat diminished in smell, but not the least dissolved. That fowl and pigeon, in which putrefaction was far advanced, in the gastric fluid of a dog and falcon, in the month of June, was reduced to a jelly in 37 hours, and had lost most of their disgusting smell: hence heat is necessary in this case; and he found that flesh which was become putrid in the craw of a cockerel, lost it on arriving in the stomach. Animals of cold blood he found much longer in correcting the putrefaction of flesh, from their slow digestive powers. Hence it appears from these experiments, that the various classes of animals, and

man among the rest, are endowed with the power not only of checking the putrefaction of substances in the stomach, but also of correcting them when already putrid. It is an antiseptic, however, which differs from other substances possessing that property; for they, while they keep away putrefaction, preserve or restore the cohesion of the parts, whilst the gastric fluid, being at once an antiseptic and solvent, preserves or corrects putrefaction by reducing bodies.

From this antiseptic quality, the disgusting manners of these animals, who delight in corrupted and putrid substances, ought no longer to excite surprise, for the food, however putrid, must be totally changed before it is converted into nutriment and animalized. In this manner the multitude of loathsome insects and worms that feed on decayed carcases, and of birds and quadrupeds, such as the crow, the kite, the vulture, the jackal and the hyena, that seem to find a pleasure in tainted flesh, may devour their savoury morsels; and whilst other animals are flying from the miasmata arising from such putrid bodies, these may enjoy their abominable repasts with impunity.

Omnivorous.

In *omnivorous* animals, Carminati observed the same or nearly the same power in their gastric juice, as in the preceding.

Graminivorous.

Graminivorous, ruminating, and nonruminating animals, were found possessed of the same antiseptic quality in their gastric juice, as, the others when it was acid; but when alkaline, it corrupts very soon, and more or less so according as the heat is greater or less, and it's alcalescency more or less strong.

We are informed by Jurine, that the gastric juice of the ox, in the common temperature, kept inodorous about 30 hours, that at the end of 48, it had contracted a fetid odour; mixed with flesh, it corrupted in 8 hours.

In an ice house, and the bottle stopped, it kept 14 days without change. It may be observed, that from this antiseptic quality, some physicians have imagined that the gastric juice might be of use as remedies, whether externally or internally applied.

APPLICATION OF THE GASTRIC JUICE IN DISEASES.

JURINE, of Geneva, Foggia and Carminati, have tried the effects of this liquor in different diseases, and with various effects. We are informed by the first physician, that, when applied *externally*, 1st. the gastric juice has the property of curing certainly and immediately the pains which arise from bad ulcers.

The gastric juice used as a medicine.

2d. That it stimulates and destroys diseased flesh, and softens the edges of callous ulcers.

3d. That it dissipates disagreeable and putrid odours arising from diseased parts.

4th. It diminishes excessive suppuration, and gives it a healthy appearance.

5th. It accelerates the cicatrix. The experiments of Carminati appear to support those of Jurine; he found that the gastric juice of rooks, and of the Royston crow, kept omnivorous by nourishing them with flesh and vegetables; perfectly cured old fetid ulcers, after having been bathed with it two or three times a day; that it produced a sensation of heat during the two or three first days of its application. He found the gastric juice of carnivorous animals possessed this property in an eminent degree, and although the heat it produces is greater than that from the crow, the cure is much quicker. He found it of

great use in bad venereal ulcers, in stopping the progress of gangrene, and in rendering the ichorous humour of the cancer more mild, taking away it's fœtid odour, and diminishing the shooting pains of that disease. The experiments of Foggia support those of Jurine, and the great beneficial effects of the application of the gastric juice of graminivorous animals in the cure of ulcers is asserted by Dr. Harnes. He has found it to succeed in more than 100 instances, where sphacelus had occurred; and testimonies of it's peculiar good effects in similar cases are given by Jones, a surgeon to the naval hospital at Bastia, and Read and Buck, two of his principal assistants. An instance of the cure of an ulcer by Dr. Harnes is the following. Thomas Corben, boatswain of the Egmont, on the 31st of July, 1796, had an ulcer on the right leg, six inches in length, and four in breadth; the margin of the surrounding integuments, with the much greater portion of the surface of the ulcer, were in a sphacelous state. The discharge was so acrid as to destroy every part it came into contact with, and it had insinuated itself through the whole length of the gastrocnemius and soleus muscles. The whole extremity was very tense, and the health of the patient much impaired. He had recourse to the gastric juice of a bullock killed for the use of the ships, from which three pints of fluid were obtained. The surface of the ulcer was washed with it, and it was injected by a syringe into the sinuses, and superficial dressings of lint applied. The third day after this application was begun, upon removing the dressings, the whole of the sphacelated parts came away, and exposed a large portion of the tibia, in two places. To these, lint dipped in the gastric juice was applied, which not only appeared to prevent discoloration and exfoliation, the usual attendants; but, on the contrary, in the course of eight days the parts thus exposed were covered with granulations,

and at the expiration of fourteen days, the whole of the soft parts were perfectly reunited, and the surface of the ulcers reduced to a fore of about two inches and half diameter, with granulations finall, compact, and of a beautiful fluid colour. Nov. 10, it was perfectly healed, and the patient attended to the duties of the ship. He took Peruvian bark, and used lemons and onions during the cure.

Used *internally* in indigestion, such as in vomitings of acid and black matter after eating, and in other diseases where the gastric juice of the stomach had lost it's energy, Carminati found it of great use. The dose was one ounce of fresh juice from the ruminating class, taken daily. Where the organ itself was affected, it was of no use. The gastric juice of carnivorous animals he found to be too irritating to an ulcer of the stomach, until it had been diluted with water. He likewise cured intermittents with it, and raised the dose to three ounces in the day. He observes that the juice of herbivorous ruminating animals, when acid, may be substituted for that of the carnivorous class, and is more easily procured.

We are informed, that Carminati was capable of imitating the gastric juice of the carnivorous class; he digested for this purpose two drachms of fresh veal in one ounce of spring water, and added five grains of common salt; it was exposed to the heat of about 100° of Fahrenheit for sixteen hours, and the liquor was then decanted. By repeated digestion with fresh flesh, he found it became much stronger and more similar to the natural gastric juice.

According to Struve, who says that the phosphoric acid and volatile alkali are the two essential principles of the gastric juice, a liquor may be made which produces a similar effect upon aliments.

DIGESTION.

If we look back into antiquity, we shall find that the earliest opinion on the cause of digestion was, that of putridity. It was by this process that both Hippocrates and Empedocles supposed the food when taken into the stomach to be reduced to a proper state for the support of the animal system.

Galen. Galen and his disciples conceived an idea that it was brought about by heat.

Van Helmont. Van Helmont, whose wild conjectures can only be accounted for by the spirit and enthusiasm of alchemy, which raged in his time, attributed digestion to the vital energy of the soul, which resided, as he thought, in the stomach.

Grew and Santarelli. Grew and Santarelli were of opinion, that the spirits which are poured forth from the nerves of the stomach served for the concoction of the food.

Boerhaave. Boerhaave, who has in reality only attempted to reconcile the variety of opinions that had been proposed before him, supposes there are two principal agents in this vital function, viz. the different fluids that are collected in the stomach, and the mechanical action of that organ. The secondary agents, he supposed, are heat, air, the nervous fluid, the remains of the food, and an incipient fermentation, opposing it in the extensive sense in which it was considered before him. With respect to the gastric fluid, his ideas appear to be indeterminate, and unsettled; he, however, conceived that its action on the food was merely as a simple diluent, like water, when heated to the same temperature. He had no suspicion of its being a solvent, or that it was capable of acting upon the more tenacious and hard substances that were taken in as food.

According to Pringle and Macbride, digestion is carried on by a complete fermentative process. The food divided by mastication, and penetrated by the saliva, begins, as soon as it enters the stomach, to be agitated by that intestine motion which always accompanies fermentation; this motion is excited by the warmth of that viscus, by the old remnants of the food, by the gastric fluid, and more particularly by the saliva, which is above all adapted to produce and promote this process. They supposed that the first effect of this intestine commotion, is to raise the solid parts of the aliment to the surface of the gastric liquor, where they will be for some time sustained by the air bubbles, which, on their ceasing, must fall down again and be thoroughly incorporated with the fluids of the stomach. This mixture is rendered still more complete by the peristaltic motion, the alternate pressure of the diaphragm and abdominal muscles, and the continual pulsation of the adjacent large vessels. In this state the food passes into the small intestines, where the fermentative motion produces still greater changes by the assistance of the bile and pancreatic juices. It is then converted into chyle.

According to the opinion of Haller, the gastric juice is more or less acid in different animals; its action on the food very much resembles that of water, in which a little salt has been dissolved, which, from experience, is known to possess a very great resolvent power; and the consequence is, that an incipient fermentation takes place which reduces the aliments to a pulaceous mass. In animals that feed on seeds, this process is assisted by trituration. These, with many other fanciful opinions, took place in their turn, when Cheselden by chance happened to conjecture right, viz. that digestion was performed by some unknown menstruum. This conjecture was confirmed by Reaumur and Spallanzani, who have proved the menstruum to be the gastric juice by a number of experiments, a gene-

Pringle and
Macbride.

Cheselden.

Reaumur
and Spal-
lanzani.

ral view of which it will be necessary to give. Spallanzani made his experiments by introducing certain substances, such as raw vegetables, &c. enclosed in small perforated tubes, and causing animals to swallow them; he then either destroyed the animal in order to examine it, or waited until it was vomited up. The animal kingdom may be divided into three kinds; those whose stomachs are *muscular*, *intermediate*, and *membranous*; the last class is infinitely more numerous than the two former.

Stomachs.

Of animals with *muscular* stomachs, such as fowls, turkeys, ducks, geese, doves, pigeons, &c. the food is seeds, such as wheat, barley, pease, &c. When it is taken spontaneously by these birds, it remains some time in the craw, where it is macerated and becomes softer; it is then conveyed into the stomach or gizzard, which is composed of very strong muscles, capable of grinding not only the grain it receives, but is of such force as even to reduce small pieces of glass, and blunt the points of needles; by this means the food is triturated and reduced very small; it is then converted, by the gastric juice it meets with in this viscus, into a pulsatitious mass called chyme. Spallanzani found, that the gastric juice of this class digests flesh, and that they are for the most part both frugivorous and granivorous. He found it dissolved raw flesh, when bruised, in about two days; but when entire, four and sometimes five days were necessary. It dissolves grain only when bruised; hence, in the gallinaceous class, trituration and the gastric fluid in the gizzard, although Reaumur was of opinion it contained no menstruum, mutually assist each other; the former, by breaking down the aliments in a mechanical way, prepares it for the latter, which penetrates it, destroys its texture, dissolves its particles, and disposes them to change their nature and become animalized. Spallanzani thinks, that this gastric fluid found in the gizzard proceeds chiefly from the œsophagus; the

chyme he found to be a semifluid pultaceous mass, of a whitish yellow colour. The transparency of this gastric juice, in a state of purity, is little inferior to water, it is fluid, and a little bitterish and saline. It retains out of the body, when warm, the power of dissolving animal and vegetable substances; but it must be fresh, for if kept in vessels, particularly if open, it loses its efficacy; it must not have been used for experiments, and likewise a heat equal to that of the bird is necessary, otherwise it has no more effect than water.

The ruminating animals of the third class, such as sheep, oxen, &c. very much resemble this class of birds in their manner of digesting substances; in both, the gastric fluid requires an agent capable of breaking down the food, before it can dissolve it. The hay and grass, in the ruminating tribe, descend immediately into the first and second stomachs in nearly the same state as when first browsed. Here they are softened by the juices, as seeds are in the craws of birds with gizzards; but as the stomachs of these quadrupeds have no triturating power, and the aliment requires trituration, it ascends, in consequence of a gentle stimulus to vomit, into the cavity of the mouth, where by means of rumination, it is put into the same state previous to being digested by the gastric fluid, as happens to the food in the stomachs of granivorous fowls, after they have been properly triturated by the gastric muscles.

Animals with *intermediate* stomachs, such as ravens, crows, herons, &c. have muscular stomachs, which are by no means equal in force to the stomachs of the first class, but much more so than those of the third class. These animals possess the privilege of returning substances they are incapable of digesting, at least every nine, and in general every two or three hours; they are omnivorous. Their gastric juice does not dissolve whole

feeds, they therefore bruise them with their beak and feet, and they are dissolved in twenty-four hours; it soon dissolves flesh and cartilage, but not bone. The fluid in the œsophagus Spallanzani found inconsiderable as a menstruum, when compared with that of the stomach, since the first was six hours in dissolving two parts of flesh, and the second one hour only in dissolving six parts; consequently the œsophagal liquor in the craws of the gallinaceous, is different from that in this class. The *resemblances* between the gastric fluids of these two classes may be reduced to five: first, these fluids, besides being alike in colour, are always salt and bitter, which bitterness proceeds from the bile regurgitating through the pylorus into the stomach. Secondly, they are the immediate agents of digestion, both in the muscular and intermediate stomachs, independently of trituration. Thirdly, the fluids act in the stomachs of these two classes of birds in the same manner, in the solution of the food; they first soften, and next convert the surface into a jelly, then produce the same effect on the intermediate parts, insinuating themselves gradually into it's substance until it is completely dissolved. Fourthly, they do not entirely lose their solvent power as soon as taken out of the stomach, provided they be heated to a proper degree. Fifthly, the origins whence these fluids spring are nearly the same, viz. the follicular glands with which their organs abound. With respect to the *differences*, they are in part reducible to the inferior efficacy of the gastric fluid in muscular, to that of the same fluid in intermediate stomachs. The gastric juice of the first is incapable of dissolving the same aliment that the latter readily dissolves. Likewise, the food which each kind of gastric juice decomposes and digests is sooner subject to this change from that which belongs to intermediate stomachs; hence, artificial digestion succeeds much sooner

with the first than the second. The same inefficacy that the gastric juices of birds with muscular stomachs shews in the solution of aliments of a firm texture, extends also to their œsophagal juices in the solution of soft substances; notwithstanding the latter are tolerably well decomposed by the œsophagal juice of birds with intermediate stomachs. Another very striking difference, is the prodigious force of trituration in muscular stomachs, and the weakness of the other, which greatness of strength was necessary in birds, whose food is of considerable firmness, as seeds.

Animals with *membranous* stomachs, such as frogs, newts, snakes, fish, ruminating animals, carnivorous birds and beasts, as the eagle, falcon, man, dog, cat, &c. This class is infinitely more numerous than the two former. It comprehends nearly all the quadrupeds, fish, reptiles, birds of prey, and the greater part of insects. From Spallanzani's experiments, it appears, that carnivorous birds do not dissolve vegetables, and throw up the indigestible part every twenty-four hours; that nature in these animals, whose digestion depends on the gastric juice alone, without any previous mastication or trituration, has provided them with a much larger quantity of it than the other classes; that digestion is in proportion to the quantity of this fluid; that the gastric juice of the ruminating class has no effect in dissolving plants unless they have been previously macerated, and ground by the teeth; that it's colour in sheep is green, and yellow in cows; that owls digest flesh and bones, but not grain; that their gastric juice evaporates sooner than water; that, that of the eagle dissolves bread and bone; it's colour is cineritious, and it digests animal and vegetable matters out of the body; that a wood pigeon may be brought by degrees to live on flesh; that the owl and falcon do not digest bread; that the gastric juice of the dog dis-

solves the enamel of the teeth ; and that trituration is necessary in the ruminating order, and man, which is produced by the teeth, as in gallinaceous fowls by the gizzard ; but in other animals, as in the frog, newt, serpents, and birds of prey, trituration does not contribute to digestion.

Hence, in every order of animals, the gastric juice is the principal cause of digestion, and it agrees in all in many properties, and differs in others. In the frog, the newt, scaly fishes, and other cold animals, it produces digestion in a temperature nearly equal to that of the atmosphere. In warm animals it is incapable of dissolving the aliment in a degree of heat lower than that of these animals. In warm animals the food is digested in a few hours, whereas in the opposite kind it requires several days, and even weeks, particularly in serpents ; likewise, the gastric juice of the gallinaceous class can only dissolve bodies of a soft and yielding texture, and previously triturated ; whilst in others, as serpents, the heron, birds of prey, and the dog, it decomposes substances of great tenacity, as ligaments and tendons ; and even of considerable hardness, as the most compact bone. Man belongs to this class, but his gastric juice seems to have no action on the hardest kind of bones. Some species, likewise, are incapable of digesting vegetables, as birds of prey ; but man, the dog, cat, crows, &c. dissolve the individuals of both kingdoms alike, and are omnivorous, and in general their gastric juices produce these effects out of the body.

Hence, the dissolving power of this fluid depends on the difference of the nourishment, and by some authors it has been said to be the cause of hunger and of the difference in the choice of the particular aliment, by which power the carnivorous only enjoy flesh ; the graminivo-

rous and ruminating, only vegetable aliments, and no flesh; but man and the omnivorous, both vegetable and animal substances.

It is, however, asserted by Carradori as decided, that nocturnal birds of prey are capable of digesting vegetables. It results from his experiments, that they also support themselves very well with this nourishment, in spite of their repugnance to it. If this be the case, the opinion is erroneous, that the gastric juice of these birds had only an affinity with animal substances; and what he has established, viz. that carnivorous animals find a nutriment in the products of plants, was already rendered probable by the discovery of Fourcroy of the existence of gluten, albumen, and gelatin in the vegetable tribes. Spallanzani, however, proves the insufficiency of Carradori's experiments, as the owl died when confined to vegetable food.

The time requisite for digestion is different in different animals. In many it does not exceed five or six hours, and in some it is much shorter.

From the numerous experiments of Goffe of Geneva Goffe. upon digestion, and the action which the gastric juice has upon different substances, great light has been afforded us upon this interesting subject.

He informs us, that in about one hour and a half after the food is taken into the stomach, it is changed into a pultaceous mass; the gastric juice, likewise, renders it fluid, without altering its nature; and when digestion is properly carried on, there is no appearance of acidity or alcalescence; the food does not ferment; and the process of digestion is not completed until the space of between two and three hours has elapsed.

The chyme which arises from aliments taken either from the animal or vegetable kingdom is the same; they

both are, by the gastric fluid, converted into the same substance, which is in consequence most probably of their both containing gelatin, &c. If, however, the digesting solvent is not in sufficient quantity, or is in a diseased state, the acetous fermentation will take place in vegetable, and the putrid in animal matter; hence milk, vegetable matter containing sugar, wine, and even spirits will degenerate, when left to their spontaneous changes in the stomach, to a very strong acid, and sooner sometimes than out of the body, perhaps from the heat, &c. All oily substances likewise become rancid, and flesh meat putrid, producing acid and putrid eructations, which is never the case in a state of healthy digestion; whilst, in many animals the digestion is finished before the acetous or putrid fermentation can begin.

Substances *insoluble* or that were not digested in the usual time in the stomach.

Animal substances.

1. Tendinous parts. 2. Bones. 3. Oily or fatty parts. 4. Indurated white of egg.

Vegetable substances.

1. Oily or emulsive seeds. 2. Expressed oils of different nuts and kernels. 3. Dried grapes, and the skins of fish. 4. Rind of farinaceous substances. 5. Pods of beans and pease. 6. Skins of stone fruits. 7. Husks of fruits with grains or seeds. 8. Capsules of fruit with grains. 9. Ligneous stones of fruits. 10. It does not destroy the life of some seeds, hence bitter-sweet, hemp, mistletoe, and other plants which sometimes grow upon trees, are produced by the means of the excrements of birds, the kernels of the seeds being defended from the menstruum by their exterior covering.

Substances *partly soluble*, or parts of which were digested.

Animal substances.

1. Pork dressed various ways. 2. Black puddings. 3. Fritters of eggs, fried eggs and bacon.

Vegetable substances.

1. Sallads of different kinds rendered more so when dressed. 2. White of cabbage, less soluble than red. 3. Beet, cardoons, onions, and leeks. 4. Roots of scurvy grass, red and yellow carrots, succory, are more insoluble in the form of sallad than any other way. 5. The pulp of fruit with seeds, when not fluid. 6. Warm bread and sweet pastry, from their producing acidity. 7. Fresh and dry figs. By frying all the substances in butter or oil they became still less soluble. If they are not dissolved in the stomach, they are, however, in the course of their passage through the intestines.

Substances *soluble* or easy of digestion, and which are reduced to a pulp in an hour, or an hour and half.

Animal substances.

1. Veal, lamb, and in general the flesh of young animals, are sooner dissolved than that of old. 2. Fresh eggs. 3. Cows milk. 4. Perch boiled with a little salt and parsley. When fried or seasoned with oil, wine, and white sauce, it is not so soluble.

Vegetable substances.

1. Herbs, as spinach mixed with sorrel, are less soluble. Celery. Tops of asparagus, hops and the ornithogalus of the Pyrenees. 2. Bottom of artichokes. 3. Boiled pulp of fruits, seasoned with sugar. 4. Pulp or meal of farinaceous seeds. 5. Different sorts of wheaten bread, without butter, the second day after baking, the crust more so than the crumb. Salted bread of Geneva more so than that of Paris, without salt; brown bread in proportion as it contains more bran is less soluble. 6. Rapes, turnips, potatoes, parsnips, not too old. 7. Gum arabic,

but it's acid is soon felt. The Arabians use it as food.

Substances which *facilitated* the menstrual power of the gastric juice, are sea salt, spices, mustard, scurvy grass, horse radish, radish, capers, wine, spirits in small quantities, cheese, particularly when old, sugar, various bitters.

Substances which *retarded* the gastric power are water, particularly hot and taken in large quantities. It occasions the food to pass into the intestines without being properly dissolved. All acids, astringents, 24 grains of Peruvian bark, taken half an hour after dinner, stopped digestion. All unctuous substances, kermes, corrosive sublimate. Gossie likewise observed, that employment after a meal suspended or retarded digestion, as well as leaning with the breast against a table, and that repose of mind, vertical position and gentle exercise facilitated it.

It likewise appears, that from the soluble power of this fluid, digestion goes on after death, but it is far less considerable than in the living animal; that in fishes it retains it's property of digesting flesh, but in an inferior degree to that of birds; and that in some animals, heat is necessary to this power which acts independent of the vital power.

Hunter attributes to the action of the gastric juice, the erosions found in stomachs of those who have died suddenly, in which, sometimes, the great curvature of that organ is entirely consumed; he often found them on opening dead bodies, the edges of the wounds appearing like half digested food. Spallanzani, however, although he agrees with Hunter that digestion may take place after death, is of opinion contrary to that celebrated anatomist, that heat is necessary.

Dr. George
Fordyce.

The opinion of Dr. George Fordyce appears to resem-

ble and support those of Spallanzani and Goffe. According to this chemist, from the nature of the gastric juice and it's action upon different substances, when the stomach is in health, so as to secrete it in it's pure state, the food is readily digested whilst in weak stomachs; if the food be in too large a quantity, or does not readily enter into the digestive process, or is a species which the stomach has not been accustomed to, the vegetable part will go into the acetous fermentation, and produce heartburn, vomiting, &c. and the animal into the putrid, whilst the putrid matter, either by it's action upon the stomach, or it's introduction into the system along with the chyle, he has known several times to produce a putrid and malignant fever.

He is of opinion that the substances taken into the stomach undergo such a change as to become all the same substance, or as it has been called chyme, and that it is then rendered capable, but not before, of being converted into chyle. The properties, however, of chyme, are at present unknown. He thinks that this process of the stomach is the most essential part of digestion.

The properties of the human chyle have not been investigated, but according to Dr. Fordyce, as far as experiment has been carried, the chyle of quadrupeds, a class of animals in which man is to be ranked as far as he is not improved by culture, is so similar as not to be distinguished, not even in natural classes the most opposite to each other in their food, structure, and habits of life. The chyle of a dog or of a wolf differs in nothing, as far as experiment has gone, from that of a sheep or of an ox.

The chyle consists of three parts, one part which is fluid and contained in the lacteals, but coagulates on extravasation.

The second part consists of a fluid, which is coagulable by heat, and in all it's properties hitherto observed, it is consonant to the serum of the blood.

The third part consists of globules, which render the whole white and opaque. These globules have been supposed by many to be an expressed oil, but this has not been proved. Neither has it been perfectly demonstrated that sugar is contained in the chyle, although it has been made very probable. The difficulty of determining these points is, the small quantity that can be collected, the largest animals not supplying more than one ounce or two, at the most. However, the part coagulating on extravasation; the part agreeing with serum in it's qualities; the globular part, which in some animals, but not in quadrupeds, exists without giving whiteness to the chyle, alone, or along with sugar, form the essential parts of the chyle.

A great many substances may enter the lacteals along with the chyle; even solids reduced to a fine powder. When indigo has been thrown into the intestine of a sheep, Dr. Fordyce has seen the chyle rendered quite blue; yet indigo is not soluble in water, but is a solid reduced to a very fine powder. Musk likewise gets into the chyle, giving it a strong smell, and a great variety of other substances of various colours, various tastes, and various smells; each of them giving colour, or taste, or smell to the chyle. The lacteals, however, reject some substances in whatever manner they are applied; amongst these are green vitriol and infusion of galls, for the chyle gives no colour when either is given with food to the animal, or thrown into the intestine, and it is afterward tried by them as tests of each other.

According to Dr. Fordyce, the chyle is not formed in the stomach. Milk is that food which comes nearest to

the chyle in it's external appearance, and as it is formed for the nourishment of young animals whose digestive organs are weak, and necessity for nourishment great, it is obvious, that chyle is ready prepared, or nearly so, in the vessels of the mother, to save the powers of digestion in the infant. Yet, on this entering the stomach, there is a juice which coagulates it in a few minutes after, retards it in the stomach, and retains it there for a considerable length of time. The same is produced on the white of egg, and serum of the blood. This of itself would sufficiently prove that there is a process which it must go through previous to it's being formed into chyle. It further appears, that food dissolved in water so as to form a solution not capable of being coagulated and not detained in the stomach, gives very little nourishment in proportion to the same quantity of the same food given in a solid form, or a coagulable one. Hence a decomposition and recombination take place, but these do not appear to be the formation of chyle. Another circumstance is, that if it was chyle, the absorbents, which are numerous in the stomach, would take it up as fast as it is produced, and would have the appearance of and actually be lacteals, and be perceived; but if a living animal be opened at any time during digestion, there is no appearance of any chyle absorbed from the stomach, and hence there is none to be absorbed. If we throw milk into a portion of the jejunum, it will be absorbed by the lacteals, but if thrown into the stomach of the same animal, the milk will not be absorbed by the lymphatics, hence it may be said that the absorbents of the stomach refuse what those of the jejunum readily take up; but the case is, that the milk is instantly coagulated in the stomach, and not in the jejunum, which coagulation will perfectly prevent it from being absorbed; but all those substances which are not changed by the coagulating juice of the stomach are

equally taken up by the lymphatics in the stomach and lacteals.

It therefore appears that the use of the stomach is only to change the food into a new substance, the chyme, which is the only substance that can be converted into chyle. When this chyme is propelled into the duodenum, it is then converted into chyle, and not before; but the duodenum cannot have this action upon it, unless it has previously undergone the action of the stomach. There is nothing, therefore, in the whole doctrine of different species of food which can have any respect to any part of the body, excepting the stomach itself; for only those parts of it that are converted into chyme will pass into the duodenum and be converted into chyle; the other parts that have not undergone this change in the stomach will pass through the duodenum unchanged, and be evacuated. So that according to Dr. Fordyce, it is perfectly immaterial what is the species of food, farinaceous matter, animal mucilage, apples, potatoes, wheat, mushrooms or oysters, beef, veal, chicken, salmon or goose. So long as it has undergone the process of the stomach, and is converted into the matter formed by that process, it gives equally good nourishment, and is equally innoxious, because it becomes exactly the same. Sometimes a little whitish matter is seen about the pylorus, but this is not perfect chyle, for it is not seen in the absorbents of the stomach, even although in the middle of digestion the pylorus be tied round by introducing a piece of tape, forming a ligature round it, and retaining the remaining food in the stomach. The matter, therefore, formed in the stomach, is converted into chyle in the duodenum, and continues to be converted in the jejunum.

As the coagulating juice of the stomach, as far as can be judged, does not enter into the matter or chyme form-

ed in the stomach from the food, nor the other juices of the stomach, only in so far as they supply water ; so neither do the juices of the duodenum, the bile, pancreatic juice, or fluids secreted in the glands of the duodenum, or which may pass through the exhalants, at all appear to enter into any part of the chyle. For, according to Dr. Fordyce, if the ductus communis choledochus be obstructed by a stone, or if the body of an animal be opened when food has been thrown into the stomach, and the duct be tied up, by which the bile is prevented from getting into the duodenum ; in either case the chyle is formed without any particle of bile being admitted ; and the same may be said of the pancreatic juice ; so that chyle is solely the product of the matter formed by the digestive process of the stomach. The chyle is always the same, but not always in the same proportion to the quantity of food. Scarcely any digestible matter is ever found in the duodenum, in the form it was thrown into the stomach ; hence all of it seems to undergo some change or other.

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BILE.

THIS is a yellowish green fluid, which is separated from Bile, the blood by means of the liver, a viscus occupying a very large space in the animal body. In man, and in the generality of quadrupeds, birds, &c. there is a reservoir attached to this organ, which contains this fluid in more or less quantity; in man, it has been computed at an ounce on an average; but in the elephant, stag, and in all insects and worms, this reservoir is wanting.

The bile in man, and in quadrupeds, &c. is not only collected in the gall bladder, from whence it is conveyed by the cystic duct, but another portion of bile is brought directly from the liver itself, and flowing into the hepatic duct, joins the cystic by the name of the ductus choledochus communis, and enters the duodenum; hence the bile may be divided into the hepatic and cystic.

1. The *hepatic bile* has not as yet undergone any chemical investigation; it is, however, said to be milder in its taste, less highly coloured, and thinner in consistence than the cystic. Two kinds.

2. The *cystic bile*, when pure and in a healthy state, is Cystic bile. of a green colour, inclining to a yellow; this, however, appears to depend on the quantity of aqueous fluid it contains; for when diluted, this yellow tinge is very conspicuous; and when in a more concentrated state, it is of a deep green. In the greater number of quadrupeds, and in man, it is of a yellowish green, but in birds, oviparous animals and fish, it is constantly green; it is likewise said to be much darker in carnivorous than in grami- It's properties.

nivorous animals. In diseases it is of all shades, from a pallid hue to a direct black ; thus in cachexy and dropsy it is very pale ; whilst in melancholia, yellow fever, and plague, it approaches more or less to a black. There are instances of it's being affected by aliments, and of it's being tinged by the use of different vegetables.

It's flavour is very bitter, accompanied with a certain degree of pungency ; if, however, aloes be mixed with it, the production is said to be a sweetish taste. This natural flavour is stronger in the bile of carnivorous than of herbivorous animals, and in oviparous quadrupeds it is said to be exceedingly pungent, but not very bitter ; and the same is the case with that of fish ; whilst examples are recorded of this fluid becoming somewhat acetous to the taste.

In consistence, it is viscous and tenacious, resembling a sirup or oil, and when agitated in a phial it foams like soap water. On it's first flowing into the gall bladder, it is more aqueous than after it has resided there some time, and at times it is found in part coagulated. This tenacity in the bile Dr. Saunders seems inclined to explain, from it's being a compound fluid, consisting in part of genuine bile, with a portion of the mucus secreted by the gall bladder.

The consistence, taste, and colour, however, are properties of this fluid which appear to depend on the same cause, for the more aqueous it is, the more light coloured and less bitter ; on the contrary, if it's viscosity be increased, it's flavour and colour are of consequence increased in strength ; and it is found to be more viscid, more bitter, and deeper coloured in the gall bladder than as it flows from the liver, from the aqueous parts being taken up by the absorbents. In adult animals in health, it is likewise more viscid, deeper coloured, and more bitter than in younger ones, whilst in the foetus, it is said to be

sweetish, very aqueous and of a reddish hue. It is likewise more viscons in man than in quadrupeds.

In diseases these differences are more evident.

It's odour is disgusting and nauseous, but in some animals, when fresh, it is said to possess an agreeable smell similar to that of musk; whilst in others, this musky smell may be obtained by evaporation, or they obtain it spontaneously by putrefaction.

It is specifically heavier than distilled water, but it differs greatly in this respect; according to Muschenbrœck, the proportion is as 1,0246 to 1,0000.

Diluted with a little water, it changes the sirup of violets green.

It is perfectly soluble in water, and affords a clear solution of a more or less yellow colour, according to the quantity of menstruum.

All the acids on being added to this fluid, decompose it in the manner of soaps and also produce a coagulation of the albumen. If the mixture be filtrated, and the liquor evaporated, a neutral salt is obtained, composed of the acid employed and soda. This beautiful experiment is due to Cadet, and shows the presence of soda in the bile. According to Fourcroy, the matter left on the filter is thick and viscous, and composed of two different substances; the one is the coagulated albumen, the other a bitter and very inflammable matter, varying in colour and consistence according to the degree of concentration of the acid employed to separate it.

The presence of soda in bile.

Albumen and resin.

These acids affect the colour of the bile; thus, by the sulphuric, a deep green is produced; the nitric, when a little concentrated, gives it a brilliant yellow, and the muriatic a very beautiful clear green. These colours, however, vary according to the state of the bile and the acids. If bile be previously diluted with water before the addition of the acids, we are informed by Hildebrandt

Acids affect it's colour.

that the part which is not coagulated remains dissolved in the water. The precipitate above mentioned has been looked upon, particularly by Van Bochante, a chemist of Brussels, (in a dissertation on the colouring matter of the bile,) as a substance analogous to the resins. On being placed upon red hot coals, it swells, melts, and inflames; it is totally dissolved by alcohol, and precipitated again by water, like the resinous juices. According to Fourcroy, the action of the acids shows, that the bile is a real soap formed of an oil analogous to the resins; united to soda, they likewise announce the presence of a certain quantity of albuminous matter in this animal liquor, which is the cause of it's being coagulated by them, as well as by heat and alcohol, as will soon appear. It is likewise this part of the bile that undergoes the putrid fermentation.

The action of acids proves the bile to be a real soap.

The colour destroyed by oxygenated muriatic acid.

According to the same chemist, the oxygenated muriatic acid destroys the colour of bile, and coagulates it's albumen, which is precipitated in the state of white flocks; the biliary soap remains in solution, which in appearance is nothing but pure water, having lost it's colour and odour, and only preserving all it's bitterness. If more of the acid has been added than is sufficient to coagulate the albumen, the excess acts by degrees upon the oil of the soap, and returning again to ordinary muriatic acid, decomposes a part of the soap and separates it's oil in a concrete form, and of a white colour. Since it appears, that it is only by furnishing the albumen with oxygen, that the oxygenated muriatic acid coagulates the bile; this chemist thinks it probable, that the portion of this acid returned to it's simple state decomposes a certain quantity of the biliary soap, and consequently, the albumen is always mixed with a little of the resin or the concrete oil of the bile.

If a simple acid, as the sulphuric or muriatic, &c. be

added to the bile, after it is become colourless by the oxygenated muriatic acid, a white concrete precipitate is immediately formed of the consistence of fat. This precipitate, which is the oil of the bile somewhat changed by the oxygen of the muriatic acid, perfectly mixes with water, and is even dissolved by the aid of heat. This property is the more singular, since the soda which renders it soluble is no longer present; having united to the acid used in the decomposition of the bile.

A white concrete oil found on adding a simple acid to the colourless solution.

This *white concrete oil* is soluble in the cold, in alcohol; and if the solution be accelerated by heat, a certain quantity of æther is formed, which appears to arise from the oxygen contained in the oil uniting with the alcohol, and changing the proportion of it's principles. The alcoholic solution exposed to the air loses it's alcohol by degrees; but it is with great difficulty that it becomes solid. If, when it is about the consistence of a syrup, it be mixed with water, it unites perfectly with it, which seems to announce, that the biliary soap has not been decomposed; but when an acid is added to this solution, a precipitation is immediately the consequence. Another experiment not less singular is, that if a fresh quantity of alcohol be put to the solution of the oil of the bile, thus inspissated by the air and water, and afterwards added, an abundant precipitate takes place.

Properties of the white oil.

It appears, that the same phenomenon of the solubility in water of this bilious oily matter, which was pretended to be a resin, had been previously observed before in the laboratory of this chemist; but it would seem, that this pretended resin, which is precipitated by an acid, is in part soluble in water, and only takes an apparent character of insolubility in this fluid, from the presence of an acid.

It was conjectured, that this white concrete oil had some analogy to the white and crystalline matter of the

Differs from the crystalline matter

of biliary
calculi.

human biliary calculi; but it was soon evident that it differs from it in several properties.

1st. It is more soluble in alcohol, and is not precipitated in small lamellæ.

2d. It is soluble in water.

3d. It is of much softer consistence and more fusible, being nearly equal to the fusibility of fat (at 32° or 33°), whilst the crystalline matter of the human biliary calculi only melts at a heat above 90° , and remains solid at a few degrees above boiling water.

Action of
salts upon
bile.

The neutral alkaline salts mixed with bile prevent its putrefaction; the ammoniacal salts are decomposed by it; the earthy neutral salts are decomposed, and precipitate it.

Metallic salts decompose it, and are decomposed at the same time by it; the soda of the bile unites to the acid of the solution, and the coloured oil of bile is precipitated in union with the metallic oxyd.

Unites with
oils.

Bile unites readily with oils, and like soaps takes out any greasy spots from cloth; hence the bile of the ox is used in cleansing stuffs.

Bile a real
animal soap.

The bile, or biliary soap as it may be properly called, is soluble in alcohol, which separates it's albumen in a coagulated state. This tincture of bile is not decomposed by water, which shows the substance to be a real animal soap, equally soluble in water and in alcohol.

It is likewise easily dissolved by æther.

Putrefies
sooner than
blood.

Dr. Saunders, in order to try whether the bile had a greater power of resisting putrefaction than the blood, put equal quantities of blood and bile of the same ox into different vessels of the same size, and exposed them to the same degree of heat, and found that on the third day the blood began to show signs of putrefaction, whilst the bile remained in it's natural state; on the fourth day the bile had a pungent odour by no means ungrateful,

whilst the blood was extremely putrid. On the 6th day the bile became putrid, and had a very offensive smell. The progress of putrefaction in bile is, according to observation, as follows:

Exposed to the air, at a warm temperature of from 15° to 25° , a change very soon takes place; it's aroma becomes at first nauseating; it's colour changes; whitish mucilaginous flocks are precipitated; it loses it's viscosity, and soon becomes foetid and strong to the organs of smell. When the putrefactive process is far advanced, it's odour becomes mild and somewhat resembling ambergris. It has been observed by Vauquelin, that after inspissating somewhat bile in the baln. mar. it keeps several months without change, as is the case with vinegar when boiled. He found that the bile of the ox, which exhaled a foetid odour, was of a dirty brown colour, and turbid; became on being heated of a beautiful green; lost it's odour whilst some albuminous concrete flocks were separated, and that it is no longer so subject to change as when it is in it's natural state. When submitted to distillation, there arises a phlegm which shews no traces either of an acid or an alkali; after a certain time it becomes putrid. This phlegm has often presented to Fourcroy a well marked, mild, aromatic odour, very analogous to that of ambergris or musk. The obtaining this aroma particularly succeeds, if the bile be distilled after it has been kept a few days, and is a little changed. The same is the case with bile, after having being somewhat inspissated, and kept a long time.

Action of
heat upon
bile.

It's musky
odour.

When bile has been inspissated, by a sufficient exposure to heat, to a more or less dry extract, it is of a deep green or brown colour, very tenacious, and of a pitchy consistency; it deliquesces, and is nearly wholly soluble in water. On being distilled the inspissated bile affords a yellowish alkaline phlegm, an empyreumatic oil, a

Products of
inspissated
bile on dis-
tillation.

large quantity of carbonet of ammonia, an elastic fluid mixed with carbonic acid, carbonated by hydrogenous and azot gases. The remaining coal is found in large quantity, and, according to Macquer, very saline; it is less difficult of incineration than that of most other animal substances. According to Cadet, who presented to the academy, in 1767, an excellent memoir on the analysis of the bile, this coal contains carbonat of soda; an animal earth, *i. e.* phosphat of lime, and a small quantity of oxyd of iron. If the bile be distilled on the open fire, great caution is necessary from it's swelling considerably. When heated to 60° it coagulates, and becomes a flocky, thready mass, which arises from it's albumen. Fourcroy has likewise observed in the products of the bile, after distillation, in the retort, and rectification, a small portion of prussic acid, partly free and in part combined with ammonia.

When bile has lost it's oil by exposure to a strong heat, it's carbon is difficult to incinerate; for we are informed by Fourcroy, that whilst it is undergoing a red heat, the soda so easily volatilizes, that the ashes being still blackish, no longer contain any alkali, and show no traces of it in water. Incineration appears, therefore, a defective process to arrive at the fixed parts of bile, and more especially to determine their proportion.

Component
parts of bile.

On collecting the component parts of the bile, it is found to contain a large portion of water; a peculiar concrescible oil united with soda, forming a saponaceous substance; and an albuminous mucilage which is coagulable. Several other substances, besides it's aroma and colouring matter, are said to contribute to it's formation. Thus, Cadet, independent of the phosphat of lime, thinks he found a salt in the coal of the bile, of the nature of sugar of milk, the existence of which Van Boechate has since confirmed; but Fourcroy is of opinion, that this

pretended saline matter is rather to be looked upon as analogous to the oily, leafy, brilliant and crystalline substance that Poulleter found in the human biliary calculus, and Hildebrandt is of opinion; that the substance which communicates a bitter flavour to the organs of taste forms an essential part of it; since it appears from the experiments of Leonhardi and Richter, that bile, even when reduced to a coal, still retained it's bitterness. Common salt and iron have likewise been said to be found in it; but according to other chemists, these are only accidental.

Opinion of
Hildebrandt
on it's bitter
taste.

The last chemist who has paid any attention to the component parts of bile is Dr. Saunders. This physician, from various experiments, concludes, that it consists, 1. Of water impregnated with the odorous principle. 2. A mucilaginous substance, resembling the *albumen*. 3. A resinous substance containing the colouring principle and bitter taste, and 4. The mild mineral alkali. With respect to their combinations he is of opinion, that the saponaceous matter consists of the bitter resin in union with the alkali; that this admits of a ready union with a mucilage, and with this again the aqueous matter.

It's component parts
according to
Saunders.

Hombërg, Bourgelat, Cartheufar, and Ramsay, have made a few experiments on it with acids and a few saline bodies, but they have contributed nothing towards the discovery of it's component parts; and, perhaps, little was done respecting it's analysis, till Cadet, by a course of well directed experiments, threw more light upon it than all his predecessors had done before him. He is said to be the first who actually discovered the presence of soda in it, although Roeder had shown the existence of it much about the same time. This fluid had, indeed, been long made use of in the cleansing of greasy and oily spots from cloth, from it's having been found to possess saponaceous properties; but independent of this,

several physicians, such as Burggrave, Hartmann, Baglivi, and Verheyen, had made some few experiments upon it, by which the presence of an alkali had been detected. It was likewise known, that by the addition of acids the gall became turbid, and that on mixing them with a solution of soap, they equally brought about the solution of an oily matter. At length the work of Gardani appeared, from whose experiments, made with great care and diligence, it was proved, that this fluid had the power of precipitating salts with a metallic basis. All these facts sufficiently show the presence of an alkaline salt, and agree very well respecting it's saponaceous property; but there remained to discover the nature of the alkali, which was effected by Cadet, in an excellent treatise on the bile, read before the Academy of Sciences, and printed in the year 1767. He found that on treating bile with the muriatic acid, he obtained by crystallization common salt; with the nitrous acid, it gave the nitrat of soda; and with vinegar, a crystallized neutral salt composed of soda and the acid employed; which experiments clearly convinced him, that the gall contained an alkali, and that this alkali was the same as that which assisted in the composition of common salt or soda; and having afterward found the same alkali in the ashes after incineration, every doubt was cleared up of it's nature.

Cadet likewise found, that the mineral acids at first produced a coagulation of the bile; but afterward dissolved and brought it to a state of greater fluidity; he confirmed the presence of calcareous earth in it by the formation of selenite on the addition of the vitriolic acid; showed, that the aqueous part of the bile contained a salt resembling the sugar of milk, and that it likewise possessed amongst it's component parts an animal fat, common salt, and a little iron.

Rœderer.

Rœderer, who, as before observed, had been engaged in

making experiments much about the same time as Cadet, or a little before, in 1767, coincided in great measure in the results. He found, that on mixing the three mineral acids with gall, he obtained from the fluid which covered the gummy resinous precipitate that fell down crystals of Glauber's salt, of cubic nitre, and of common salt; a clear proof of the presence of mineral alkali in this animal fluid. He thought, however, that this alkali appeared to be in part saturated with muriatic acid; for the coal of the bile, besides some oblong crystals that effervesced in the air, (but which ought not to have been taken for Glauber's salt without further proof, being certainly mineral alkali,) afforded him likewise cubic crystals that decrepitated in the fire. He, likewise, as well as Cadet, found the presence of calcareous earth in bile from the production of selenite with vitriolic acid; but the existence of iron had escaped his notice; he however thought he had found an acid in it, and that it had the power of coagulating milk; but Cadet proved the contrary, and conjectured that the acid, if it existed, might have arisen from the gelatinous part of the bile.

With respect to the saponaceous nature of this fluid, Different opinions of it's saponaceous nature. opinions have been different, some contending for the affirmative, others asserting the negative. The idea of it's being a soap originated from it's cleansing property; but this is only one of the properties which a real soap possesses; hence, other experiments were necessary to arrive at the truth. Gefner was not able to dissolve suet either with the aqueous solution of dried gall, which had been kept a year, or with fresh ox bile. Schroeder was likewise unable to bring about a solution either of the resinous or oily substances in bile. Rœderer found, by experiment, that the fat oils united better with bile than with soap, but that their union with the last was more

durable; that bile did not entirely refuse to unite with ethereal oils; but that, old oil of turpentine excepted, it was not able to bring them to any solubility in water, and that it showed not the least solvent power upon the resins. It was in consequence of these experiments and others, which several chemists had given to the world, to prove that bile cannot be mixed either with ethereal or fat oils or butter, or render those bodies soluble in water, that some chemists affirmed, more particularly Schroeder, Goldwitz, and Jacquin, that bile ought not to be considered as a soap; and the last has concluded, that if it be employed with success for removing spots out of cloth, the reason is, that the bile has a greater affinity with the cloth than the fat oils, which are consequently disengaged and issue in drops. Leonhardi is, however, of opinion, that as it appears from decomposition, that bile contains volatile as well as fixed alkali, with oily parts in it's composition, and that since it can unite fat oils with water, although the union is not so lasting as when soap is used, the saponaceous character cannot be entirely denied it. Robert had affirmed, in a dissertation, entitled, *An bilis sapo acido-alcalinus*, Paris, 1759, that there was a double soap in bile, an alkaline and an acid one; but he could not support his assertion by any chemical experiment. Macquer concluded, that it possesses a peculiar property approaching to a real soap, consisting of fixed mineral alkali, and such a quantity of oil as is necessary to give rise to such a saponaceous mixture as bile is allowed to have. At last, Fourcroy, as before mentioned, added greater light by his experiments on this subject, and proved, that it is an oily and saponaceous substance, composed of an oil nearly approaching to the state of spermaceti, together with a quantity of liquid albumen.

With respect to the component parts of bile, Durande

and Willink had attested the presence of iron in it; but neither Maclurg, by means of galls, nor the experiments of Leonhardi were able to detect it; and the latter is of opinion, that it is only accidentally met with in this fluid. Goldwitz endeavoured to prove that oil, air, alkali, and iron were not contained in it; that the lacto-faccharine species of salt was only accidentally present in ox gall, and only then in the spring; and that its component parts, besides coagulable lymph, consist of a liquid peculiar to it formed of water, phlogiston, and a very small quantity of earth. That bile contained no alkali this chemist concluded, because it did not effervesce with acids, which every alkali ought to do; and Stræhl, who published a book at Gottingen, *de Bilis Natura*, in 1787, supported Goldwitz in his opinion. On the contrary, Richter undertook the defence of the existence of an alkali in bile. He found, that the experiments of Cadet and Rœderer were entitled to every claim of veracity; for each of the mineral acids, after being added to this fluid, formed a coagulated and more or less green or yellow coloured precipitate; and the fluid above it, on evaporation, afforded a neutral salt, of the same nature as that which the mineral alkali forms with the same acids. With vinegar an arborescent crystallization arose, which, however, he would not affirm to be acetated soda; he likewise obtained common salt by means of dissolving the extract in alcohol. Having incinerated the coal from bile, and made a ley of it, he got by the addition of vitriolic acid Glauber's salt by evaporation, whilst a portion to which no acid had been added afforded mineral alkali; he also, on incineration, observed a smell of garlic, which called to mind the presence of Proust's salt, or the mineral alkali united to phosphoric acid. Leonhardi is of opinion, that the alkali certainly exists in bile, either in a free state or imperfectly saturated

Opinions of
it's consti-
tuent parts.

with the phosphoric acid ; for in his experiment with the fresh bile of the pig, which, according to Delius, approaches the nearest to the human, litmus paper became much darker, and turmeric paper of a brownish red. With respect to common salt, it appears from the supplement to Richter's Memoir, by Delius, that it's presence was detected in human bile by the microscope, in the form of cubic crystals, as well as the presence of an ammoniacal salt of a cruciform shape. Leonhardi thinks, that the volatile alkali obtained in the distillation of bile is certainly united with an acid. Richter obtained an oil from bile, but in very small quantity, by distillation ; and Priestley showed the presence of phlogiston on treating the extract with nitrous acid, and producing nitrous gas ; whilst other animal substances treated in the same manner only afforded phlogisticated air. Gren believed there was a resin in it from the solubility of a part of the extract in alcohol, and that this bitter resinous part was united with water, lymph, alkali, and gelatin, the remaining component parts. The bitter part appears to Leonhardi to be fixed, since the coal, both in his experiments and in those of Richter, was found to have a bitter flavour. He thinks it not improbable, but that this bitter matter may consist of the saccharine acid, deprived in part of it's fixed air, and united in different proportions with oily or inflammable parts ; which acid, according to Berthollet, is found in animal as well as in vegetable bodies. Flour spoiled by moisture, rotten apples, and rancid fat oils, all have a bitter taste. These contain acid of sugar and lose fixed air. Bile appears to this chemist, by it's bitterness, to oppose and prevent the extrication of fixed air, so that the fat parts of the chyle do not become rancid, the gelatinous parts putrid, nor the mucilaginous parts, capable of the vinous fermentation, &c. ; besides, according to the experiment of Milman, bile impregnated

with fixed air is longer in becoming putrid than without it. From this short and general history of the experiments upon bile, it appears, that it is to Cadet and Rœderer we are indebted for the discovery of the presence of soda in that fluid, which is acknowledged to exist in a disengaged state; and to Fourcroy for the knowledge of it's other component parts.

USE OF THE BILE.

THE grand object of chemistry in the analysis of animal substances is to assist the physiologist in discovering the nature and utility of the matter subjected to his investigation, and to endeavour not only to account for it's formation, but to lay before the physician the means which may be employed to protect or absolve it from the action of disease. The variety of opinions which have been given on the use of the bile, is a great proof of the obscurity in which this function is enveloped; and should the conclusion, that has been drawn from the analysis of this fluid, not be rendered perfectly satisfactory, it is at least to be hoped, that it may stimulate the scientific chemist and physiologist to redouble his efforts on so curious and interesting a subject of inquiry.

Various
opinions on
the use of
the bile.

The constancy of the bile in every animal, even in insects and worms; the size of the viscus that prepares it, and the destructive and grievous consequences arising from it's diseases, are very convincing proofs of the important part it acts in the animal economy. The great purpose to which this fluid is destined, according to physiologists, and more particularly those of the present time, is that of assisting the process of digestion; and Fourcroy, to whom we are indebted for so many experi-

ments on the subject, is of opinion, that to promote and facilitate the digestive process, is one of it's uses. He thinks, that it's soapy quality renders it capable of uniting the oily parts of the alimentary matter to water; that it's bitter flavour indicates it's being a stimulus to the intestines; and that it favours their action upon the aliments. It appears to him, that it is decomposed in the duodenum by the acids which exist, or which are almost always forming in the organs of digestion; and that at least it is certain it is very much changed, particularly in it's colour, when it becomes a portion of the excrements to which it communicates the yellow hue.

Some of the ancients as well as moderns, looked upon it in a very different light. Galen and Paracelsus were of opinion, that it was nothing but an excrement; Roux, that it's principal office was to evacuate the colouring part of the blood from the body; and Lister affirms that it is of no use whatever.

With respect to it's use in digestion, if the formation of chyle be the object, Dr. G. Fordyce has proved, that if the ductus communis choledochus be obstructed by a stone, or tied up artificially in animals, it does not prevent the formation of chyle; hence the bile can be of no use in that process.

Fourcroy. Fourcroy seems to think, that it is destined for another purpose besides digestion. He is of opinion, that the blood, as it circulates through the mesenteric, splenic, and hepatic arteries, and afterward into the divisions of the vena portarum, undergoes great changes in it's nature; whether, as physiologists say, it dissolves and takes with it some of the fat of the inferior abdominal region, which is scarcely possible; or rather, on traversing these different regions very gradually, the carbon it contains unites with the oxygen, which, as it were, has only been interposed between the molecules of it's compo-

ment parts during respiration in passing through the lungs; and consequently being a long time in regaining that viscus, it assumes a fat character from the superabundance of hydrogen which it communicates to the organs it nourishes and supports. If this be the effect in man and in quadrupeds, whose respiration is so perfect, in the vessels through which the blood circulates with rapidity, it ought to be infinitely more marked in those animals who are able to live a long time in the mud or moist infectious filth without breathing, and when respiration does take place, is only in a very limited and imperfect manner, from the smallness of their respiratory organs, and the consequent admission of a very small quantity of air; which air cannot be intimately united with the humours for a long time after it's reception, from the slowness with which they circulate. Hence these amphibious animals are more or less soft and cartilaginous, pale, and even colourless throughout their composition; have very little sensibility, and are without agility. This chemist has drawn these conclusions from the component parts of the bile, from finding traces of oil sometimes on tearing or cutting the human liver, and that of quadrupeds; from the liver of the ray containing more than half it's weight of oil perfectly formed; from certain parts of the lower belly in diseases of the liver taking a fat character, and becoming white or rather gray like the liver of the ray; from the livers of flying animals, particularly of birds exposed to a high temperature, and fed on milk, taking the same character; and from the size of this viscus in amphibious animals when compared to others, and the liquidity and oiliness of their brain, which may be attributed to a very limited respiration.

Dr. Saunders looks upon the particular office of the Saunders. bile to be a stimulus to the intestines, keeping up their

energy and peristaltic motion. It is also said, that by virtue of it's alkaline nature it corrects acidity, resists fermentation, and in consequence of it's bitter quality, retards the putrefactive process.

Is not the
bile merely
an excre-
ment?

If I may be permitted to hazard a conjecture upon the use of the bile, and the viscus that secretes it, it would appear, as Fourcroy has well observed, that the liver has a great connection with the lungs, not only from the facts already mentioned, but from the large size of this viscus in the foetus which has not yet respired; and that whatever action the bile may have upon the food, or on the intestines in digestion, there is reason to believe that the liver deprives the blood which passes through it of some of it's noxious parts, performing an excrementitious operation in the abdomen, whilst the lungs are acting to the same end in the thorax. This appears probable, not only from the large size of the liver in those animals of limited respiration, but even the extent of this viscus in man and quadrupeds, which is by far the most voluminous gland in the body, indicates, that it's action must be of greater extent than that of furnishing a mere secretion. All the glands form their secretions from the blood in it's most perfect state, or as it circulates through the arteries; whilst on the contrary, the liver makes use of the impure venous blood, supplied by the vena porta; which blood has been said by some, although denied by others, to be in a state of greater fluidity, and to have a putrescent tendency, so as scarcely or not at all to be coagulated; or in other words, possessing a superabundance of soda, which preserves it's fluidity, and of carbon and hydrogen, which give it a dark colour. If this be the case, it is probable, that as this blood circulates through the liver, this viscus deprives it of the hydrogen and carbon, which, united to a little oxygen, form an oily matter,

and meeting with the soda, a saponaceous substance is produced, which forms the principal character of the bile. Hence arises the necessity of this fluid being made with constancy and regularity, for the integrity of all the functions; and the reason of it's existing in all animals, and of it's being as necessary as the evacuation of the lungs during respiration. In those animals whose respiratory organs are very small in comparison to their body, and where the carbon and hydrogen must be in large quantity in their blood from the want of proper evacuation, the liver is remarkably capacious and great in proportion, by which means these substances are evacuated in the form of bile, the act of respiration being inconvenient to their mode of life. It is by such means that these two viscera assist each other, (*vide* animal oils). To this opinion of it's being an excrementitious matter, may be added several other properties of a like nature, viz. it's nauseous and disgusting smell and taste.

It appears, from the experiments of Fourcroy, that the oily part of the bile is nearly in the state of spermaceti, preserving it's fluidity during a state of health. When, however, this matter is too abundant to remain in solution in the bile, it becomes crystallized, forming the calculi of the gall bladder, or gall stones, which, on analysis, evidently appear to owe their formation to this oily concretible matter; and this matter being contained either in the pores or parenchymatous substance of the liver, often proves the source of several of it's diseases.

To conclude, whatever may be the functions of the liver, and the use of the bile, many experiments are necessary before any real proof can be had that is perfectly satisfactory; and as much may be brought against every opinion which authors have yet given, it follows

that the liver fulfills an operation, the whole of which science has not embraced.

Haller's Element. Physiol.—Encyclop. méthod. tom. 2. chimie. p. 564.—Cadet, Experiences chimiques sur la bile des hommes & des animaux, in the Mém. de l'Acad. de Paris, 1764; also his Nouvelles Recherches pour servir à déterminer la nature de la bile, *ibid.* 1769.—Jo. Mich. Roederer, Experimenta circa bilis naturam. Argent. 1767.—Schroëder, Experimenta ad veriozem cysticæ bilis indolem de clar. capt. sect. 1. Gotting. 1764.—Sebastian Goldwitz neue Versuche zu einer wahren physiologie der Galle. Bamberg, 1785.—Guil. Mich. Richteri experimenta & cogitata circa bilis naturam, imprimis ejus principium salinum. Acc. Henric. Frid. Delii de bile humana Epistola. Erlang. 1788.—Jacquin's Elements, —Macquers Wœrterbuch von Leonhardi, article Gall. —A Treatise on the Structure, Œconomy, and Diseases of the Liver, &c. by Wm. Saunders, M. D. F. R. S. &c. London, 1795.—2d edit.

SALIVA.

THIS, when fresh and in a healthy state, is a transparent colourless liquor, without aroma or flavour, and is secreted into the mouth of an animal to assist in the mastication of it's food. It's properties.

It's specific gravity, according to Haller, is to water as 1960 to 1875.

In carnivorous animals, it is said to be somewhat acid, and manifestly saline; and in the human subject, in disease, from having no flavour becomes bitter, sharp, sweet, sour, putrid, or saline, and sometimes it is said to partake of several of these flavours at the same time.

In consistence, it is somewhat less fluid than water, but more so than mucus; it does not freeze so soon as water, and when mixed with air, is converted into froth.

It is imperfectly soluble in water.

It mixes imperfectly with oils to a milky fluid.

It has no action on the tincture of litmus or syrup of violets.

Alcohol in some measure coagulates it.

Acids in small quantity produce a flocky appearance, in large quantity they dissolve it.

According to Plenck, caustic alkalis and lime extricate ammonia from it.

From Pringle's experiments, it possesses a septic quality.

In a warm atmosphere it soon runs into the putrid fermentation.

It appears to have a slight action on some of the metals, as iron and copper. Acts upon iron and copper.

It's component parts.

It's component parts appear to be four-fifths of water, albumen, according to Plenck ammonia, and an animal earth, which, according to Weber, contains muriat of soda, to which he has added calcareous earth.

Brugnatelli found the saccharine acid in the saliva of a venereal patient, whose disease was of long standing.

Boerhaave says, it promotes the vinous fermentation, on which account the Indian women are accustomed to chew the maize before they mix it with water, to promote it's fermentation; it is then used as an agreeable drink.

Helvetius the alchemist expected to find in it the philosopher's stone.

Saliva of the horse by de la Chenier.

From the above account of the analysis of the human spittle, little was known concerning it's component parts; but a more detailed analysis has been made by Hapel de la Chenier on the saliva of the horse, which it will be necessary to give some account of.

He collected it whilst the animal was feeding, by making a puncture into the duct of the salivary gland; by this means he procured twelve ounces of it in the space of 24 hours.

It's properties when examined externally, and by reagents.

It's colour was of a light greenish yellow, soapy to the touch; it's aroma weak but disgusting; it's flavour saline; it's consistence thin, but by repose it became less fluid.

On exposure to the air, it became putrid in fourteen days; was covered with a brownish mouldy pellicle; became thinner, darker, and in six weeks was dry, resembling a blackish earth. It does not undergo the acetous previous to the putrid fermentation.

Exposed to dephlogisticated air, this fermentation was retarded.

In boiling water it coagulated in part, which coagulum was not soluble in water.

Alcohol acted in the same manner, and precipitated

the coagulable part in the form of flocks, which were not only soluble in ammonia but in water.

Vitriolic acid diluted, coagulated it, and the remaining fluid afforded small crystals of Glauber's salt, after filtration and evaporation.

Nitrous acid made it clammy, and a deposit soon took place.

Marine acid made it tougher, the other acids thickened it more or less.

The coagulated part formed by the acids was not soluble in water like that procured by alcohol, but ammonia dissolved it perfectly, and it was again precipitated by acids.

Solutions of the alkalis and neutral salts had no effect on this saliva; nor did caustic alkalis or lime water produce any smell of ammonia.

It precipitated metals from their solutions.

Earthy neutral salts caused a deposit.

Oils and resins become united with water by stirring them with the saliva; hence Chenier says, that it may serve to extract the fat from cloths like a soap.

In the heat of boiling water it became thinner and deposited flocks, whilst there went over on distillation a fluid disagreeable both in smell and in taste, which was neither acid nor alkaline. The residuum resembled dried mucus, and became moist on exposure to the air; distilled in a glass retort, it produced a lemon coloured very alkaline fluid, which changed the syrup of violets green; and an oil of the same colour, which swam on the surface. In the neck of the retort were crystals of volatile alkali, coloured by the oil; a thick, black, empyreumatic oil, which fell to the bottom of the liquor; then inflammable and fixed airs; there remained in the retort a coal, and the inside was lined with a metallic splendour, which remained in it a quarter of a year.

The coal was difficultly incinerated, and the lixivium afforded crystals of muriat of soda:

| | | drmi. | grs. |
|---------------------------|--|-------|---------|
| Obtained by distillation. | He obtained by this distillation, of water | 1 |5 |
| | Ammonia - - | 0 |3½ |
| | Thick empyr. oil - | 0 |5 |
| | Inflam. and fixed air | 0 |5 |
| | Coal - - - - | 0 |6¾ |
| Total | | 1 |30 |

From Chenier's analysis, this saliva consists of air, water, mineral alkali, common salt, and an earth which he takes to be the earth of bones.

Saliva taken from the mouth of the horse, in which it is mixed with other fluids therein, tastes very evidently saline, and is of a more mucous consistence than the other taken from the duct. It feels very slimy, has a nauseous smell, but affords the same products by distillation as the other. Chenier found, however, that with lime and the caustic alkalis it produced a smell of ammonia, which was not the case with that from the duct.

From this statement of the analysis of this fluid, it shows how imperfect our chemical knowledge is of it at present; a great many more experiments being necessary before it's component parts are sufficiently understood.

A great analogy has been observed between this fluid and that which is secreted from the pancreas; their use appears to be the same, and both of a saponaceous nature.

Plenck's Hygrologie des Menschlichen Körpers. art. Speichel.—Brugnatelli, in the Journal de Physique. p. 214. 1788.—Hapel de Chenier sur la salive d'un cheval, in the Histoire de la Societe Royale de Médecine, à Paris. p. 327, 333. an. 1780 & 1781.—Weber's Untersuchung der Thierischen Feuchtigkeiten. Tubingen. 1780.

TEARS.

BEFORE the experiments of Fourcroy and Vauquelin, this secretion had never been analysed; it is even very difficult to procure a sufficient quantity of it for examination, which may be one reason of it's having been neglected.

The tears, when in a healthy state, are clear and transparent as water, they are without any aroma, their flavour is evidently saline. Their properties.

Their specific gravity is somewhat greater than that of distilled water.

On exposure to a dry air, they evaporate spontaneously to dryness; and toward the end, cubic crystals arise in the midst of a mucus, which serves them as a mother ley. These were found to be the muriat of soda, and soda in a free state. As the tears thicken on exposure, they become by degrees more yellow. They undergo no evident change from the impression of heat; on evaporation, the aqueous part first comes over, and at the boiling point a foam appears, which is to be attributed to their mucous quality; then an oil, and there remains a dry yellowish substance, scarcely amounting to 00,4 of the quantity employed, which is a coal containing the phosphats of lime and soda in small quantity, being scarcely perceptible; they have no effect on the tincture of litmus, but change paper coloured by violets to a green, which proceeds from the soda.

When fresh, they unite with cold and hot water in all proportions, if, however, they have been previously ex-

posed to the air, so as to have received from it a certain consistence and a yellow colour, as before observed, they remain unchanged, although from the foamy appearance of the water on agitation, a small portion seems to have been dissolved. By continued exposure, however, they become less and less soluble, which seems to arise from their union with oxygen.

Unite with
oxygen.

Alkalis unite readily with them, by which they are rendered more fluid, and this is the case after they have attracted oxygen.

Of all the acids, the dephlogisticated muriatic only affords any thing remarkable on this fluid when fresh. It is coagulated by it into white flocks, and becomes yellow as when exposed to the air; these flocks, like inspissated tears, are insoluble in water. The acid, by losing its smell and properties, shows that it has parted with its oxygen to the tears, and accounts for the gum which is formed at the angles of the eyes during sleep.

The sulphuric and muriatic acids have no effect on fresh tears, but produce an effervescence when they are oxygenated. In the first case, sulphat of soda remains mixed with the mucous part; in the second, muriat of soda.

Alcohol, added to fresh tears in sufficient quantity, precipitates the mucous part in the form of large white flocks. If the spirit be separated from the mucus and evaporated, traces of muriat of soda, and of soda, appear, and by this method the proportion between the saline and mucous parts may be found.

Analysis.

From the analysis made by these two chemists, it appears that tears are composed of a peculiar mucus, which, after their water, forms the greatest portion of muriat of soda, phosphat of lime and soda, which last forms so

small a part as to be scarcely perceptible, to which Plenck has added phosphat of soda. From the limpidity of this fluid, it had been considered by many as water nearly in a pure state; amongst these was Pierre Petit, a Physician of Paris, who published a Treatise on the Tears, about the end of the last century. Some observers, as Schoëner, &c. have likewise seen the formation of crystals in them, and they produce alkali according to Blasius; but further investigation is necessary before we can arrive at their component parts.

NASAL MUCUS.

THIS secretion is without flavour or aroma. It is a transparent colourless fluid when it is fresh and thin; but when thickened, it is of a slight greenish yellow.

It's properties.

It's consistence is clammy, adhering to any thing it touches.

This secretion is more copious in childhood than at a state of puberty.

It's specific gravity is somewhat greater than that of water. It swims at first on the surface of water, but sinks to the bottom as soon as the air is extricated from it.

Exposed to the air, it becomes hardened into pulverizable shining leaflets.

On a red hot coal, it is nearly all evaporated without any disagreeable smell, which is not the case when it is united with a little pus.

It neither unites with cold or warm water, nor is diluted by them; neither is it dissolved by boiling water; since, according to Plenck, it falls to the bottom on cooling.

It has no action either on the tincture of litmus, or syrup of violets.

It appears to unite, in some measure, with limewater.

It does not unite oil with water like vegetable mucus.

It is neither soluble, according to Plenck, in neutral, nor carbonated alkaline salts, but by the caustic it is decomposed.

The acids thicken it somewhat in small quantities; in large they dissolve it, and produce different colours.

The vitriolic acid gives it a purple red colour, and dissolves it, except a few lumps which fall to the bottom.

The muriatic acid dissolves it totally, with an amygdalaceous colour.

The nitrous acid when concentrated dissolves it with a yellow colour.

Of all animal fluids, it appears to be one that is the least subject to putrefaction. It remained a month, according to Plenck, exposed to warmth in water without any smell.

Mucus appears to be the same as fibrin of the blood, with this difference, that it contains a little gelatin.

For the examination of the nasal mucus in a diseased state, we are indebted to Fourcroy and Vauquelin; the person from whom it was taken had an inflammation of the schneiderian membrane, or what is commonly called a cold, which is the best time to obtain it in any quantity.

At the commencement of this disease, the mucus is clear and transparent as water, its smell scarcely observable, its flavour saline and somewhat sharp; in this state it has a great resemblance in its properties with the tears; it contains like them muriatic soda, and some particles of phosphate of lime. To this may be added, that these two chemists having procured some of this nasal mucus quite pure from a person who had the inferior extremity of the lacrymal duct obstructed so as to prevent the admixture of the tears, found it perfectly to agree in its properties with that fluid.

When this humour runs more slowly, toward the end of the disease, it remains longer attached to the sides of the nasal cavity, and there it undergoes several alterations; it becomes thickened by the heat of the inflammation, whilst the inspired air deposits a portion of its oxygen as it passes over it, and produces a puriform consistence and yellowish or greenish colour. On expiration, a part of the carbonic acid uniting with the soda of the mucus, gives

it the property of precipitating lime-water and barytic salts.

Since, therefore, the nasal mucus has more constantly the access of air than the tears, the last being only exposed to it upon the surface of the eyes, and from it can only imbibe the oxygen, it follows that the nasal mucus contains more viscous matter, has more tenacity than the tears, and on thickening, is generally of a more yellow colour than the tears in the nasal sack.

These chemists found, that the mucus obtained by the inspiration of dephlogisticated muriatic acid gas through the nose had very similar properties to that obtained by a common cold, except that the first portions contained no soda, nor changed the blue colours of vegetables to a green. At first the mucus flowed in great abundance, and was transparent as crystal; but afterward it became somewhat inspissated, and put on the yellowish, greenish appearance of pus.

From these appearances, there is great reason to attribute this artificial cold to the oxygen of the marine acid, since it was found that the fumes of other acids, which contained no oxygen in a free state, produced no such action.

Plenck, art. *Thranen*—*Examen chimique des Larmes, and de l'Humeur des Narines, &c.* par Messrs. Fourcroy et Vauquelin. *Journal de Phys. Sem.* 2. p. 254. 1791. & *Annal. de Ch.* p. 113. v. 10.

PUS.

THIS, in a healthy state, is a whitish fluid, secreted from the surface of an inflamed part, and is of the consistency of cream. It's properties.

It's flavour is mawkish, and it's aroma when warm is peculiar to it, when cool it is inodorous.

We are informed by Home, that when examined by the microscope, it is found to consist of two parts, viz. of white globules and a transparent colourless fluid.

It's specific gravity is greater than that of water.

It does not readily go into the putrid fermentation.

According to Hildebrandt, by a moderate warmth it undergoes the acetous fermentation.

Heat does not coagulate it, but evaporates it to dryness.

By the dry distillation, Brugmann informs us, it gives an aqueous fluid, which is neither acid nor alkaline, then becomes thick and brown in colour; in a strong heat, it affords an alkaline spirit, and ammonia in a fixed state, an empyreumatic oil, and leaves a blackish shining coal, difficult to incinerate. The ashes are very small in quantity and of a dark reddish colour.

When placed on red hot coals, it produces an animal aroma and inflames.

It does not unite with water in the heat of the atmosphere, but falls to the bottom; if, however, a considerable heat be applied, it rises, and is diffused through the water; and remains mixed with it even after cooling; the globules appearing to be decomposed.

Pus, from gonorrhœa, and the small or chicken pox, has the same appearance as that from a healthy ulcer.

It has no corroding action on flesh.

It shows the presence neither of a disengaged acid nor alkali.

Vitriolic acid, when concentrated, dissolves it, forming a darkish purple colour. On diluting the solution with water, the dark colour disappears, and the pus separates again in the form of a porous substance, part of which swims at the top, the other sinks.

Concentrated nitrous acid produces with it a lemon-coloured solution, and the addition of water separates a gray coloured substance from it.

Strong muriatic acid forms with it an ash gray coloured solution, from which water separates the pus in its natural state.

Carbonated potash, according to Hildebrandt, mixes with pus, and about twelve times as much distilled water heated to 100° of Fahrenheit, and becomes of a gelatinous ropy consistence. Bad pus only gives a weak gelatin.

Neutral salts have no action upon it.

Caustic alkalis form with it a homogeneous, ropy, whitish fluid; the pus is again perfectly separated by water and acids.

Alcohol thickens it by attracting its aqueous particles, but does not dissolve it.

Oils mix with it, but have no action in their mild state.

Distin-
guished
from mucus
by Darwin.

Much has been said respecting the distinguishing properties of pus and mucus, and an ingenious Dissertation has been written by Charles Darwin upon this subject, who draws the following conclusions from his experiments: 1. Pus and mucus are both soluble in the vitriolic acid, though in very different proportions, pus being much the less soluble. 2. The addition of water to either of these compounds decomposes it; the mucus, thus

separated, either swims on the mixture or forms large flocci in it; whereas the pus falls to the bottom, and forms on agitation an uniform turbid mixture. 3. Pus is diffusible through a diluted vitriolic acid, though mucus is not; the same occurs with water or a solution of sea salt. 4. Nitrous acid dissolves both pus and mucus; water added to the solution of pus produces a precipitate, and the fluid above becomes clear and green, while water with the solution of mucus forms a dirty-coloured fluid. 5. Alkaline lixivium dissolves (though sometimes with difficulty) mucus, and generally pus. 6. Water precipitates pus from such a solution, but does not mucus. 7. Where alkaline lixivium does not dissolve pus, it still distinguishes it from mucus, as it then prevents its diffusion through water. 8. Coagulable lymph is neither soluble in diluted nor concentrated vitriolic acid. 9. Water produces no change on a solution of serum in alkaline lixivium, until after long standing, and then only a very slight sediment appears. 10. Corrosive sublimate coagulates mucus, but does not pus.

The author thinks, therefore, that *strong vitriolic acid* and *water*; *diluted vitriolic acid*; and *caustic alkaline lixivium* and *water* will serve to distinguish *pus* from *mucus*; that the vitriolic acid can separate it from coagulable lymph, and alkaline lixivium from serum. And hence when a person has any expectorated material, the composition of which he wishes to ascertain, let him dissolve it in vitriolic acid, and in caustic alkaline lixivium; and then add pure water to both solutions, and if there is a fair precipitation in each, he may be assured that some *pus* is present; if in neither a precipitation occurs, it is a certain test that the material is entirely *mucus*; if the material cannot be made to dissolve in alkaline lixivium by time and trituration, there is reason to believe that it is *pus*.

According to Salmuth, who has examined this method of distinction, the criterion which that ingenious youth wished to establish cannot be relied upon, hence other methods have been proposed.

Home.

We are informed by Home that the property which characterises and distinguishes pus from most of the animal substances is it's being composed of globules. This property was first observed by John Hunter, and is an accurate means of knowing healthy pus.

Home found that mucus, and every other animal substance affected by the action of putrefaction, appear to be composed of flakes when examined by the microscope; that this property of being composed of globules shows that pus has a great affinity to the other animal secretions, although in many circumstances it may differ from them; viz. it differs from the blood in the colour of the globules, in their not being soluble in water, whilst those of the blood are, and from the fluid in which they swim being coagulable by a solution of sal ammoniac, which serum is not.

It differs from chyle in it's globules being larger; not coagulable on exposure to the air, nor by heat, whilst those of chyle are.

The globules of the pancreatic juice are much smaller.

Those of milk are nearly of the same size as those of pus, though much more numerous; but milk coagulates by rennet, which pus does not; and likewise contains oil and sugar, which are not to be discovered in pus.

To try the comparative action which pus in the body, and pus and jelly out of it, had on flesh, Home put a piece of flesh into a healthy abscess, and equal weights of the same he immersed in equal quantities of pus and jelly in two glasses, which were kept nearly in the temperature of the human body; and it appeared that in twenty-

four hours the flesh in the abscess was quite sweet; that in the pus had a slight putrid smell, and had decreased in size; that in the jelly was become smaller and finer in its texture. In six days the flesh in the first was lessened, but quite sweet; in the second it was dissolved in ninety-six hours, whilst that in the jelly was not putrid, but much smaller. The muscle in the abscess was preserved a few days longer without undergoing any change or diminution in weight.

To determine this distinction likewise between pus Grafmeyer. and mucus, Grafmeyer has lately proposed the following experiment. The substance to be examined is mixed by trituration with an equal quantity of tepid water, a saturated solution of perfectly aerated potash, equal in weight to the substance, is added, and the mixture being gently agitated is set aside. If the mixture be pus or mixed with it, a transparent tenacious jelly will separate in a few hours; on the contrary, if the mixture contain no pus, it will remain unchanged.

On distillation Brugmann obtained from $8\frac{1}{2}$ ounces of pus, in a heat of boiling water, $7\frac{1}{4}$ of a transparent water without smell, which contained neither an acid nor an alkali; by a strong heat, 3 drachms of an empyreumatic ammoniacal fluid; 2 scruples of the same mixed with an oil, $\frac{1}{2}$ drachm of dry ammonia, and $\frac{3}{4}$ of an ounce of an empyreumatic oil, and the remaining coal contained, when incinerated, iron, calcareous earth, and no salt.

In a state of disease, as in scrofulous abscesses, pus In a diseased state. consists, according to Home, of globules and flaky particles floating in a transparent fluid; the flaky part is greater in proportion to the smallness of the inflammation; and in those abscesses unaccompanied by inflammation, their whole contents are curdly and flaky; whilst in irritable ulcers the discharge is often thin, being

In the cancer, by Crawford.

principally composed of an aqueous fluid of an irritating nature, and very much inclined to become putrid. According to Crawford, the pus from the cancer constantly changed the sirup of violets green, which he attributes to it's containing ammonia; and potash produced no change in it. Sulphuric acid coloured it brown, and disengaged with an effervescence a disagreeable odour resembling sulphureous hydrogenous gas. From his experiments Dr. Crawford concludes, that this pus contains a principle possessing many properties of hepatic air, which he thinks is combined with the ammonia, and he calls it animal hepatic gas. This pus, diluted with water and distilled, afforded at first the air of the retort charged with the cancerous odour; this was succeeded by some whitish vapours with a putrid odour. When the water was entirely evaporated, a new gas arose exhaling the odour of burnt bones, with some empyreumatic oil. It appears, therefore, to Dr. Crawford, that the stinking odour of this pus is a volatile substance, which forms the nidus for the cancerous poison.

Dr. Crawford is of opinion, respecting the matter of the cancer, that chemical changes and combinations take place; his reasons for thinking so are, that in the cancer, and in malignant ulcers, the animal fibre undergoes nearly the same change as in dry distillation. The purulent matter necessary to the cure of the ulcer is in this case mixed with the animal gas and ammonia.

This composition, which may be called an ammoniacal sulphure, attacks metals and decomposes metallic salts, for when it is enclosed a few days upon mercury, it changes it's surface to a black colour, and it immediately precipitates the solution of nitrat of silver of the same colour. These facts appear to Crawford to explain what takes place on applying metallic salts to a malignant ulcer, the ammonia unites to the acid of the salt, and the hepatic

animal gas reduces the metal by seizing it's oxygen. (According to Crawford, by restoring to it the inflammable principle).

It is probable, that the metal thus reduced is sometimes attacked again by the ammoniacal sulphure, which gives it a black colour. The same origin may be ascribed to the black crust formed on the tongue and in the mouth, when venereal ulcers of the throat are washed with a solution of corrosive muriat of mercury; to the obscure colour which cataplasms made of the acetite of lead have upon bad ulcers; and to the change which sounds sometimes undergo after having been introduced into the sinuses of such ulcers, or applied to carious bones. Hence, undoubtedly, is the reason of polished metals so easily tarnishing on exposure to the putrid effluvia of animal substances.

Hepatic animal gas, Dr. Crawford found, communicates a green colour to recent fat; it renders animal fibres soft and flaccid; it accelerates putrefaction; hence it is a septic, and it is very probable that the composition resulting from it's union with the ammonia, contained in the liquor running from an open cancer, produces deleterious effects and aggravates the disease. It is the ammoniacal sulphure that communicates to the cancerous matter it's putrid odour, it's tenacity, and all the properties that distinguish it from ordinary pus.

According to Dr. Crawford, therefore, a substance capable of decomposing the ammoniacal sulphure, and of destroying the fetor of the animal hepatic gas, without increasing the mortification of the vessels, would necessarily produce salutary effects. The nitric acid only destroys this fetor at a high degree of concentration, and in this state it is corrosive. On the contrary, this gas is deprived of it's fetor as soon as it is mixed with the oxygenated muriatic acid, even diluted with three times it's

weight of water; the application can then be made without danger, provided the cancerous ulcer be not very irritable.

In the hospital sore
by Cruickshank.

The matter of the *hospital sore*, which is produced, according to Dr. Rollo, by a poison *sui generis*, as are the venereal, scrofulous, cancerous, and variolous sores, has been examined by Cruickshank.

This matters appears to be sparingly soluble in water; but being readily diffused through it produces a milkiness.

It produces no effect on the infusions of litmus or Brazil wood, hence is neither acid nor alkaline.

Pure ammonia reduces it to a transparent jelly, and after some time dissolves the greater part of it; the same happens to pure pus.

Acids, and particularly the sulphuric, precipitate but partially these solutions.

The solution of nitrat of silver, poured into the filtered aqueous solution of this matter, occasions a whitish precipitate.

The same effect is produced by the nitrat and muriat of mercury; but the precipitate is much more abundant. When pure pus is treated in the same manner, these precipitates, particularly that by muriat of mercury, have somewhat of a different appearance, difficult to describe.

Limewater rather changes it's fetid odour, but does not destroy it; sulphuric acid increases it; alcohol, and a solution of the oxyd of arsenic in potash, produce the same effect. This fetor resists the decoction of Peruvian bark; on the contrary, it is destroyed by the nitrats and muriats of mercury, by the nitrous acid, but more completely by the oxygenated muriatic acid, either in a liquid state or in the form of gas. The nitrat of silver produces very little change either in it's colour or odour;

which is the more remarkable from this salt having the property of destroying the most offensive odours, even that of the matter of the cancer.

Cruikshank is of opinion, that the bad odour of this matter of the ulcer is produced by a change of one part of the true pus; for every ill conditioned discharge has more or less smell, while good pus has none; and since it is a principle in chemistry, with only few exceptions, that the odour of a substance cannot be entirely destroyed without changing it's properties at the same time, there is reason to think, that if the odour of this peculiar morbid matter be entirely destroyed by the addition of the nitrat or muriat of mercury, the oxygenated muriatic acid, &c. it's properties will be likewise changed.

Supposing then, that an acid matter produced by some means on the surface of a sore is able to produce ulceration of a specific kind, and that this ulceration, like that of the venereal viscus, is able to propagate itself by forming a similar matter, or even to induce a general affection of the system; there are several important consequences might be drawn from these experiments.

1st. A sore, once clean, might be preserved from the effects of the matter alluded to, and even it's generation prevented, by washing it at every dressing with a weak solution of nitrat of mercury, or with the oxygenated muriatic acid.

2d. When this matter begins to form, it's progress may not only be stopped, but that already formed may be destroyed by the application of a proper topic. In this case, the above experiments show, that the most preferable are the most active mercurial preparations, such as the muriat of mercury, or the precipitated red oxyd of the nitrat of mercury, which has not been entirely edulcorated. If it be necessary to employ actual caustic, the best method is that of Humpage, which consists not

in the application of the nitrat of silver, but in applying to the part a small piece of linen dipped in some concentrated nitrous acid, which occasions less pain than the other.

Respecting the action of different substances employed as caustic applications on sores, they may be distinguished into four.

1st. Substances producing a violent action, so as to occasion the death of the part to which they are exposed, such as

Arsenic,

Muriat of mercury.

2d. Substances acting simply by burning or destroying the part, the action of which is always limited, as

Nitrat of silver,

Nitrat of mercury,

Nitric acid.

3d. Substances acting as menstrua, the action of which it is difficult to limit, as

Common lunar caustic,

Mixture of potash and lime.

4th. Substances acting chemically on the part, by decomposition as

Oxygenated muriatic acid, either

united with water or

in a state of gas.

Dr. Rollo.

We are informed by Dr. Rollo, that by chemical means he was so fortunate as to destroy the morbid poison of the hospital sore; for this purpose he made use of the oxygenated muriatic acid, the nitrats of silver and of mercury, and the oxygenated muriatic acid gas. He began by washing the sore with warm water; the ulcerated part was then immediately touched with the nitrat of silver; the sore was afterward moistened with a diluted solution of nitrat of mercury, or

a mixture of oxygenated muriatic acid and distilled water, and the whole was then covered with a linen cloth which had imbibed both. The oxygenated muriatic acid gas was also applied to the ulcer, and the diluted solution of nitrat of mercury on the whole of the fore. By this treatment the fore soon became cicatrized, and it only failed when the ulcer was too extensive to be entirely acted upon by the nitrat of mercury or the oxygenated muriatic acid gas.

Home on Ulcers.—Hildebrandt's *Anfangsgrunde der Ch.*—S. I. Brugmann, *Dissertat. de Puogenia*. Gron. 1785.—Experiments establishing a Criterion between mucaginous and purulent Matter, by Charles Darwin. Litchfield, 1780.—Henr. Salmuth de *Diagnosi Puris*. Goett. 1783.—Hermann Grafmeyer's *Abhandlung von Eiter und den Mitteln ihn von allen andern Feuchtigkeiten zu unterscheiden*. Gottingen, 1790.—Pus of the Cancer by Dr. Crawford, *Annales de Chim.* tom. 12. p. 149.—An account of two cases of the Diabetes mellitus, by J. Rollo, M. D. with the results of the trials of various Acids and other Substances, in the treatment of Lues venerea, by Wm. Cruickshank, 2 vol. Dilly, London, 1797, and *Annal. de Ch.* No. 86, p. 209.

SYNOVIA.

THIS is a transparent glutinous fluid, which is secreted between the articulations of animals to preserve them from friction. The nature of this fluid was very little known before the experiments of Marqueron on that of the ox.

It's properties. It is of a whitish green colour, has an animal aroma resembling that kind of mucus found on the exterior of frogs.

It's flavour somewhat saline.

It's specific gravity is greater than that of distilled water. On being taken from the joints it becomes of a gelatinous consistence, but does not continue long so, it is then as tenacious as before; at last it is fluid and gives a deposit. If, however, it be filtrated on being received from the joints, it does not become gelatinous.

It changes green the blue colour of vegetables, and precipitates lime from it's aqueous solution.

It unites with water and makes it gelatinous; even one part of synovia gives six parts of water very evidently this property. The mixture effervesces on agitation; if boiled, it loses it's transparency and receives a milky colour, and there arises to the surface a coagulated lymph; but although one part of the glutinous mass has been thus separated by boiling, the mixture still retains a glutinous appearance. If a very diluted acid be added to this mixture, there arises a singular effect, whether in the warm or cold way. It becomes in an instant quite tough, which toughness it loses on being stirred. It then becomes clear and transparent, and a peculiar substance separates which is gluey and elastic. For this experiment vinegar is the best, as a concentrated acid causes

no separation. The remaining liquor still retains some albuminous matter, which on evaporation appears in the form of a pellicle.

Carbonated alkalis mix readily with synovia; but caustic render it fluid.

Concentrated acids precipitate a flocky substance from it, which is soluble again in the acid. When diluted, they coagulate it.

Alcohol, without depriving it of its glutinous appearance, likewise separates a flocky matter from it.

By distillation it shows nothing peculiar; there arises a water which easily putrifies, an empyreumatic oil, and ammonia. In the remaining coal alkali and muriat of soda are found on lixiviation; and when incinerated the ashes afford phosphat of lime.

Hence it shows the properties of the white of the egg. It is soluble in water and in an alkali, with which last it effervesces on agitation; it coagulates by heat or by acids or alcohol; but it appears to demand further investigation, since it is a peculiar liquor that contains two species of albumen: 288 grains of synovia by chemical analysis afforded

| | | |
|-----------------------------------|----------------------|-----------|
| Albumen in a peculiar state | 34 grs. | Analysis. |
| Common albumen | 13 | |
| Muriat of soda | 5 | |
| Carbonat of soda | 2 | |
| Phosphat of lime | 2 | |
| Water | 232 | |
| | <hr/> 288 grs. <hr/> | |

According to Hatchett, 480 grains of synovia did not yield more than one grain of phosphat of lime.

Mémoire sur l'Examen de la Synovie, par M. Marqueron, Journ. de Phys. sem. 2. p. 463. an. 1792.

SPERMA VIRILE.

THE component parts of this secretion were but little understood before the experiments of Vauquelin, which have not, however, thrown any light on the causes of it's very extraordinary properties.

Consistence. Semen, as it comes from the body of a young healthy person, presents itself under two forms : one part is fluid and milky, and the other of the consistence of a thick mucus, in which is to be observed a number of white shining threads, more particularly if it be agitated in cold water.

According to Plenck, it is yellowish in the testicles, and of a dark yellow colour in the vesiculæ seminales ; by frequent emission it is whitish. In persons under the jaundice, and those who have taken saffron, it is yellow, whilst in a person who had the black jaundice it was black.

Examined
by the mi-
croscope.

Lewenhöeck, Hartföecker, Baker, Haller, Buffon, and Spallanzani, have amused themselves with the examination of this liquor under the microscope, in which they observed numberless animalcula or vermiculi, the last has even written their history, whilst various theories have arisen from the speculative mind of genius, to account for the process of generation from the appearance of such minute beings.

CrySTALLIZA-
tion.

In Rosier's Journal de Physique for January 1784, p. 437, is a memoir in which the author observes, that if this liquor be examined from the 12th to the 72d hour after it's extraction, and before it becomes putrid, and is in a tranquil state, from the death of these animalcula, each drop is found to contain a number of very small, light, brilliant crystals, either swimming on the liquor

or suspended in it. This experiment must be tried in a place where no dust can molest it, and where the heat is neither above 25° nor below 5° of Reaumur. These crystals are spindle-shaped, or rather consist of cones opposed at their basis, and the sides of which, instead of being straight lines are rather convex; some are isolated, others in groups, their dimensions varying from $\frac{1}{30}$ to $\frac{1}{300}$ of a line in a diameter. Some of these are even so large as to be seen by the naked eye; they neither deliquesce nor effloresce. It appears that this saline substance is not found until after a certain degree of spontaneous evaporation. These crystals seem to have escaped the observation of Haller, and some other natural philosophers who have examined this liquor. They saw no crystals, although they were very desirous to complete its analysis. He tells us, that this liquor, distilled in a sand bath, afforded a phlegm, a quantity of fetid oil, a little volatile salt, and a good deal of earth. We are, however, not informed of what this volatile salt was composed; it could not be the crystallized salt above mentioned, which appears to have been a neutral salt, nearly insoluble in alcohol, not volatile, far from deliquescing, and only soluble in a very large quantity of water; it likewise appears to exist entirely developed in the seminal liquor, in which there could be no appearance of ammonia at so early a period. These crystals, however, which the author of the memoir appears to be so desirous of being brought to light, are most probably the same which Vauquelin found in his examination, an account of which will be given.

According to Vauquelin, the flavour of this fluid when fresh is sharp, pungent, and somewhat astringent, contracting the organs of taste; its aroma is insipid, like that of most other animal substances. On the contrary, we are told by Plenck, that its aroma is of a peculiar kind,

Experiments according to Vauquelin. Its properties.

very strong to the organs of smell, and not unpleasant. That the same smell is found in the roots of orchis, in the down of chefnuts, and in the anthers of several plants. In some quadrupeds, this aroma is so strong and penetrating in the season of their amours, as to taint the flesh; hence the flesh of the goat at this period is not eatable.

With respect to it's specific gravity, it differs according to circumstances, but it is always heavier than distilled water, in which it immediately sinks to the bottom if it has not previously imbibed a few particles of air. If rubbed in a mortar it becomes pituitous and thick, resembling pomatum, which Vauquelin attributes to the admixture of air. When fresh, it changes the blue colours of vegetables to a green, and precipitates calcareous and metallic salts from their solutions, all which indicate the presence of a disengaged alkali.

Curious appearance.

The thick mucous part of the semen, on losing a part of it's caloric, becomes transparent and of more consistence than when just emitted; but it's greatest peculiarity is, it's becoming fluid again in a few hours when cool. It likewise diminishes in weight in proportion to the loss of caloric, &c. These appearances are not to be accounted for from the knowledge we have of this fluid at present.

Exposed to an air of 10° or 12° of Fahrenheit, after having undergone this change to a fluid state, it becomes covered with a transparent pellicle, and after three or four days Vauquelin found a deposit of some very delicate transparent crystals, about a line in length, some of them in a cruciform position. Examined by a magnifier, these crystals appeared in the form of quadrilateral columns, terminated by very elongated quadrilateral pyramids, and were phosphorated calcareous earth, which it had previously held in solution. In a few days more

this pellicle becomes thicker, full of white round corpuscles; the liquor becomes more fixed, and it's aroma somewhat resembles sweet whey. If from the state of the atmosphere the evaporation goes on very slowly, other crystals form of different shapes. Sometimes they are rhomboidal plates, at other times six sided or rectangular prisms, or octoedral, and Vauquelin found them to be soda which had united with the carbonic acid of the atmosphere. At the temperature of 18° or 20° this semen becomes semitransparent like horn, and snaps between the fingers.

If the temperature be greater, as at 20° of Reaumur, the air moist, as at 75 of the hygrometer of Saussure, it is changed before it has time to evaporate to dryness; it becomes yellow like the yolk of an egg, sour, and smells like putrid fish. Vauquelin, likewise, found it covered with the byssus septica.

Caloric has very little sensible action upon fresh semen; it only accelerates it's liquefaction, and when in this state it does not coagulate it, as it does many other animal substances.

If the caloric applied be so great as to separate it's principles, the aqueous part is first expelled, it then becomes evaporated to dryness, swells, blackens, emits yellow empyreumatic ammoniacal vapours, and leaves a light easily inflammable coal, which, by lixiviation and evaporation, affords rhomboidal crystals of carbonat of soda, and the remainder, on incineration, is reduced to white ashes which contain phosphat of lime.

Fresh semen is not soluble either in cold or hot water, but when evaporated to dryness it is soluble in both, and it is separated from them in the form of white flakes, either by alcohol, or dephlogisticated muriatic acid,

Acids dissolve it, and the solution is not afterward decomposed by alkalis.

Coagulated
by dephlog-
isticated
muriatic
acid.

The dephlogisticated muriatic acid is, however, an exception; for instead of dissolving fresh semen, it coagulates it into white flakes, which are insoluble in water or acids. The same takes place if the semen be in a liquid state. It is observed by Vauquelin, that a large quantity of the acid gives it a yellow colour, like the thin matter of a gonorrhœa; this is owing to the fixation of the oxygen, for the acid loses its odour afterward.

Alkalis, when sufficiently strong, facilitate its union with water.

Lime has no effect on fresh semen, but after its exposure to a moist atmosphere for some time, a considerable quantity of ammonia is produced.

Neutral salts are not decomposed by it even in a liquid state; but the case is otherwise after a long exposure to the air when the rhomboidal crystals are formed.

It's analysis. According to Vauquelin's analysis, one hundred parts of human semen contain of

| | |
|------------------------|----|
| Water | 90 |
| Fibrin | 6 |
| Soda | 1 |
| Phosphat of lime | 3 |

Total 100

Conclusion. From the facts already mentioned in the investigation of this animal secretion, it appears, that there are many curious circumstances attending it,

1. It's becoming fluid out of the body.
2. It's insolubility in water before it's fluidity, and it's solubility afterward.

These two properties, Vauquelin is of opinion, arise from it's animal and mucilaginous nature.

3. The solubility of the phosphat of lime in this liquor.

4. It's crytallization by so moderate an evaporation.

Observation sur la Liqueur seminale, *Journal de Physique*, p. 437. Jan. 1784.—Expériences sur la Sperme humaine, par M. Vauquelin, *ibid.* p. 58. fév. 2. 1791.—*Tracts on the nature of Animals and Vegetables*, by Spallanzani. Creech. 1799.

HUMOR A VESICATORIO.

It is a well known fact, that when cantharides are applied to the skin in the form of a plaster, an elevation of the cuticle takes place, and the blister is filled with a fluid resembling water in it's external appearance. For the examination of this serum or serosity, as it has been called, we are indebted to Margueron. His principal intention was to discover it's nature, and to what class of humours it belonged ; on which account he analysed it both in a state of health, and when taken from patients labouring under putrid fevers. He found that by frothing with water, by it's coagulation with alcohol, boiling water, acids and heat, and from the different salts it contained, it resembled the serum of the blood ; and on comparing them together, he concluded that the great difference between them consisted in the odour and colour, the serosity being of a darker or amber colour, and possessing the smell of the blistering plaster. The fluidity of the serum, however, was more viscous, whilst the serosity on coming from the vesicles afforded a pellicle. The specific gravity of the serum to the serosity was as 305 to 300, and 200 parts of each gave, on analysis, the following proportions.

Examined
by Margue-
ron.

Resembles
the serum of
the blood.

Difference.

Analysis.

| | SERUM, | SEROSITY, |
|-----------------------|-----------|-----------|
| Albumen | 40 | 36 |
| Muriat of soda | 4 | 4 |
| Carbonat of soda | 3 | 2 |
| Phosphat of lime | 2 | 2 |
| Water | 151 | 156 |
| | <hr/> | <hr/> |
| | 200 | 200 |

This chemist is of opinion, that the colour is caused by the action of the vesicatory in exciting heat, inflammation, &c. as he found the colour the same whether it was procured from a healthy or diseased person. From these experiments, therefore, it appears, that the serosity and serum are similar in their properties and both extracted from the blood.

This analogy induced this chemist to examine that serosity or aqueous fluid produced by sinapisms, by burns or scalds, and by the sting of insects, or by the ant, as well as that which is the effect of cutaneous diseases; and he found on submitting them to experiment, that they had all the same properties as the serum of the blood, and consequently that all arose from the same origin.

Examen chimique de la Sérosité produite par les Remèdes vésicaire, par M. Margueron. *Annal. de Ch.* tom. 14. p. 225.

HUMOR HYDROPSIS.

Resembles
the last.

THE fluid which is secreted in the various species of dropsies of the body, is likewise similar to the last mentioned liquid. It is in general somewhat yellow, scarcely turbid, and resembles even in it's external appearance the serum of the blood. It has a peculiar smell, which in some cases, as in the milk fever, is apparently acid. It is saline to the taste, and tinges violets green. Left to itself, it first becomes turbid, and at last putrefies. Boiling water coagulates the greater part of it; poured into hot water it forms a milky fluid which is incoagulable by nitric acid. It is also coagulated by all acids; alkalis rather dilute it, and when mild, precipitate in a few hours a gelatinous substance which is considered as a proof of the presence of pus. The white, opaque, and seemingly unctuous membrane (*pseudomembrana Ruysehii*) which often accompanies this humour in dropsies, agrees in it's properties with the fibrous part of the blood, and with it's buffy coat. By heat, or exposure to air, it dries into a horny substance, but in moist air it speedily putrefies. When triturated with water, it forms an imperfect solution, from which mild alkalis precipitate a gelatinous matter.

Jacqujn's Elements of Chemistry: p. 363. 1799.—
Buckholz Chemische Untersuch. der Feuchtigk. von
cinem Wassersucht. Crell's Annal, 2. 1786.

LIQUOR AMNII.

It is stated by Haller on the authority of several respectable authors, that the human liquor amnii is not very unlike the serum of milk in it's properties, even in it's odour; that it is somewhat saline to the taste, and is coagulated by alum, alcohol, and the infusion of galls. Some authors who look upon this fluid to be the food of the foetus in utero, are likewise inclined to believe that it has all the properties of albumen or the white of the egg, which is the nourishment of the chicken before it breaks the shell, and so far it favours their hypothesis; great care should however be taken in making experiments of this kind, that the mind be unbiassed by any previous prejudice, as in such cases it often is apt even to deceive itself. Haller's opinion.

A few years ago, this aqueous fluid was chemically examined by a Dutch chemist, Van der Bosch, whose veracity is as much to be relied upon as that of those quoted by Haller, or those authors who have written since upon the subject. Van der Bosch. This chemist applies the fruit of his experiments to physiology, and attempts to prove that the foetus in utero receives no nourishment from this fluid.

He examined the liquor amnii of the cow and that of the human female, and found that it's quantity is in the inverse proportion of the size of the foetus, and that in the first stage of pregnancy it's weight exceeds that of the foetus from twenty to one hundred times. It's colour during the first months is clear, or has a slight yellow hue, but towards the birth, it is turbid, flocky, and

sometimes has a reddish tinge. It's smell is scarcely observable, resembling the steam of a newly-slain animal. It's specific gravity is not very different from that of common water, but at birth it is somewhat heavier and gives a copious deposit. From experiments, it consists for the most part of mere water, and is of all animal fluids the most aqueous. It does not coagulate by any means. It contains an exceedingly small quantity of common salt and fixed alkali, and a very little phosphoric acid. It produces less volatile alkali and empyreumatic oil than any other animal fluid. It contains a little earth and red calx of iron, and the constituent parts and properties of that of the cow in the first months of pregnancy were found perfectly to agree with that of the human female, procured at the time of delivery, except that it is more aqueous.

From these facts, the author concludes, that although the liquor amnii has been commonly compared to the white of the egg; yet this last coagulates by heat and acids very readily, the liquor amnii not at all; and for the same reason it differs from serum of the blood, and the liquor pericardii.

It does not agree with whey, for this last contains a large quantity of an essential saccharine salt, the liquor amnii none at all.

It differs from animal broth or soups, for it does not coagulate in the cold, or undergo the acetous fermentation.

Lastly, it differs from urine, for it scarcely contains an atom of volatile alkali, whilst urine affords it in large quantity; and the author affirms that it's use is to protect the fœtus from external pressure; that it assists in expanding the womb, renders the parts supple, and is of great service at the time of delivery.

With respect to the coagulation of this fluid, it appears from the experiments of John Hunter, that it contains but a very slight quantity of matter coagulable by heat. John Hunter.

The most perfect and detailed analysis of the liquor amnii, has been made by Buniva and Vauquelin; they not only examined that of the human female, but likewise that of the cow. Supposing there would be great similarity between the liquor amnii of different animals, they began with the human, but they soon found that no such resemblance existed, and that no two things were more unlike than the human and that of the cow. Buniva and Vauquelin.

LIQUOR AMNII OF THE HUMAN FEMALE.

Human liquor amnii.

1st. It has a mild and insipid odour like all the white fluids of animals. It's properties.

2d. A slightly saline flavour.

3d. It's colour is somewhat milky, owing to a caseous matter which is suspended in it, for it may, by filtration, be obtained clear and transparent.

4th. It's specific gravity is as 1005.

5th. It foams considerably on being agitated.

6th. On exposure to heat, an opacity is produced resembling that of milk greatly diluted with water, and a smell of the boiled white of an egg.

7th. It strongly changes the tincture of violets to a green, but slightly reddens the tincture of litmus.

8th. Potash produces a flaky precipitation of animal matter, which seems to have been dissolved by a slight acid.

9th. Acids only clarify it.

10th. Alcohol produces a flaky precipitation, which

being collected and dried, is brittle and transparent as glue.

11th. A very large brown precipitate is formed with the infusion of galls.

12th. The nitrat of silver produces a white precipitate, insoluble in the nitric acid.

From these properties, these two chemists conclude that the human liquor amnii contains,

1st. An albuminous matter resembling that of the blood, appearing to be held in solution by a slight acid.

2d. A muriatic salt, with soda for it's basis.

3d. A small proportion of alkaline matter. It appears difficult to admit the presence of an acid and an alkali at the same time in this liquor, in a free state; and indeed these chemists do not say there is really an acid, but that it acted as if it contained one, for it reddens the tincture of litmus, is precipitated by caustic potash, and deposits by fermentation an earthy animal matter, from which ammonia is extricated.

Evaporation
of it.

On evaporation, the liquor amnii, 1st. becomes slightly milky. 2d. There arises a transparent pellicle on it's surface. 3d. A residue is left, the weight of which at most amounts to 0,012 of the whole.

The edulcorated residue, on evaporation, afforded crystals of muriat and carbonat of soda. The animal matter, lixiviated, gave, on being burnt, a fetid and ammoniacal odour, nearly like that from horn; there remained a few ashes composed of carbonat of soda, of phosphat and carbonat of lime.

It's compo-
nent parts.

These experiments prove that the human liquor amnii only contains a very small portion of saline and animal matter, dissolved in a large quantity of water, since the different substances together scarcely amounted to 0,012 of the liquor, and these are albumen, soda, muriat of soda, and the phosphat of lime.

The liquor amnii kept in a closed bottle undergoes in the course of a few weeks a putrid decomposition; it loses its transparency, and deposits a white matter like cheese. During this change, a little ammonia is evolved, but no gas or bad smell.

Putrid fermentation.

CASEOUS MATTER.

Caseous matter.

THIS substance is white and shining, soft to the touch, and resembling newly made soap. It is insoluble in water. Alcohol, even with the assistance of heat, has no effect upon it. Oils do not unite with it. Caustic alkalis dissolve a portion forming with it a kind of soap, at least judging from its odour, flavour, and the property of being precipitated by acids. It decrepitates like salt upon red hot coals, then becomes dry, blackens, and sends forth empyreumatic oily vapours. Lastly, a large quantity of coal is left difficult to incinerate.

Its properties.

Heated in a crucible of platina, it likewise decrepitates, and an oil exudes from it. It shrivels like horn, inflames, and leaves a gray cinder that effervesces with acids, the greater part of which is composed of carbonate of lime.

From these properties it would appear, that this caseous substance is a mixture of animal mucilage and fat; but it is more probably a peculiar substance, the origin of which these chemists attribute to a degenerate state of the albuminous matter, taking a fat character. This change is not more extraordinary than the conversion of the fœtus into fat on remaining in the uterus beyond the natural time.

Its composition.

It is this kind of matter which is found deposited upon the body of the fœtus, particularly under the armpits, behind the ears, and on the groins, where it is sometimes

in large quantity. It serves by it's softness, unctuousity, and it's impenetrability to water, to anoint the skin of the foetus, and prevent any bad effects of the liquor amnii; at the same time it favours it's birth during delivery.

Liquor amnii of the cow differs from the human.

LIQUOR AMNII OF THE COW.

THIS liquid differs from that of the human subject; 1st. By a fallow red colour. 2d. An acid flavour mixed with a bitterness; an odour resembling certain vegetable extracts. 3d. A specific weight equal to 1.028, and by a viscosity approaching that of a solution of gum.

Properties of it.

1st. It reddens strongly the tincture of litmus.

2d. It forms a large precipitation with the muriat of barytes.

3d. Alcohol separates a large quantity of reddish matter from it.

Evaporation.

On exposing the liquor amnii of the cow to evaporation, a thick foam was formed, easy to separate, in which, when cool, some white slightly acid crystals were observed. It became thick, viscous, and yellow, like a kind of honey, of which it had nearly the shade. Treating this matter with boiling alcohol, it afforded an acid, which, on the cooling of the liquor, crystallized into shining needles, several centimetres in length. The extractive substance being insoluble in alcohol, remains in the form of a gluish compact pitch. In order to deprive it completely of it's acid, it is necessary to boil it several times in a large portion of alcohol, and by evaporating the menstruum, the acid it dissolves is obtained.

An acid obtained, the amniotic.

To prevent any of the extractive matter from being dissolved with the acid in the alcohol, the liquor amnii must be evaporated to a thick consistence, for humidity favours

it's solution. It was by treating in this manner the residuum, that these chemists discovered an acid in this liquor; but they found afterward that alcohol was not necessary to separate it, that it was sufficient to reduce the liquor to one fourth, to obtain, on cooling, the greater part of the acid. It is indeed much whiter and purer when extracted by alcohol, from being deprived of all the animal matter that may remain attached to it's crystals, formed in a thick fluid; but it can be purified by washing it with a little cold water, which readily dissolves the extractive matter, and scarcely at all the acid. (*Vide* acids, amniotic acid.)

The liquor amnii being deprived of it's acid, if the evaporation be continued until it has acquired the consistence of sirup, large transparent crystals are formed that are very soluble in water and of a bitter colour. These chemists found it to be the sulphat of soda. It is in pretty large quantity. To obtain it pure they burnt the residuum of the exsiccated liquor, and by lixiviating the ashes, obtained a solution which afforded on evaporation perfectly pure crystals of this salt.

THE EXTRACTIVE ANIMAL MATTER:

The animal
extractive
matter.

THE animal matter which accompanies the above salts in the liquor amnii of the cow, these chemists found to be of a peculiar nature, with no perfect resemblance to any at present known.

It is of a brown red colour, has a singular flavour difficult to describe; it is very soluble in water, and insoluble in alcohol, which even separates it from the water. This last property, with that of giving viscosity to water, and the faculty of foaming on agitation, seems to give it a relation to mucous substances; but it differs from ani-

It's properties.

Composi-
tion.

mal mucilages by not being convertible into a jelly, and not combining with tan; besides, the ammonia, the prussic acid, and the empyreumatic oil, prevent it's being looked upon as a vegetable mucilage. Exposed to the fire, it swells very much, emits at first an odour like burnt mucilage, afterward that of an empyreumatic and ammoniacal oil; lastly, the odour of prussic acid is strongly perceived. After inflammation, it leaves a very voluminous coal, easily incinerated; the ashes are very light and of a beautiful white colour; are soluble in acids without effervescence, and formed of phosphat of magnesia, and a very small quantity of phosphat of lime. This animal matter is decomposed by the nitric acid, but it does not form (at least in any observable quantity) any vegetable acid, which is the case with the greater part of substances belonging to the organic kingdom; during it's action, carbonic acid and azot gases are formed, mixed with nitrous gas.

Such are the principal facts relative to the principles contained in the liquor amnii, the formation of which is at present unknown.

Haller's Physiol.—Differtatio Chem.—Physiolog. de Natura & Utilitate Liquoris Amnii à Hubertus Van den Bosch. p. 54. Utrecht, 1792.—Extrait d'une Mémoire sur l'eau de l'amnios de femme et de vache, par les Cits. Buniva et Vauquelin. An. de Ch. No. 99. p. 269. 1799.

SOLIDS.

ALTHOUGH the solids may be said to form the greatest part of the animal body, their component parts are much less known, and their analysis much less advanced than that of the fluids, or perhaps of any other parts that have yet been submitted to chemical investigation. They have been divided by authors into red and white parts; amongst the first, the muscles or flesh and the liver have as yet only been examined; the second division comprehends the brain, skin, the cartilages, tendons, ligaments, cellular membranes, the aponeurosis, and periosteum.

Their division into red and white.

1. Red parts. These derive their colour from the red particles of the blood, which circulate in their vessels; whilst in animals, in which the red particles are not permitted to circulate, the muscular parts are of a white colour, as is the case in the generality of fishes, &c.

MUSCLE OR FLESH.

NEUMANN, who submitted different kinds of flesh to distillation on the open fire, obtained from them the common products of animal substances, *i. e.* more or less of what he called an urinous spirit, volatile salt, and an empyreumatic oil; whilst the black coal remaining behind afforded a fixed salt.

Muscle examined by Neumann.

He was of opinion, that the nutritious matter of animal flesh is a substance of the gelatinous kind, and that water, by long boiling, dissolves and extracts it much more readily and completely from some sorts of flesh

than from others. This author gives us the method of making portable soup; as he informs us, that if the coc-tion be performed in close vessels, and the liquor properly evaporated to a due consistence, a solid extract may be obtained, which is a very serviceable preparation, for when thoroughly dried it keeps well, and may be again dissolved by warm water into a liquor resembling the soup or fresh decoction.

Geoffroy.

According to the experiments of Geoffroy on a pound of the flesh of the ox, sheep, and calf, it appears, that the flesh of the first affords the least soluble substance, and that the proportion of the extract and fibrous part insoluble in water, as well as of the humidity contained in them, is the following :

| | Ox. | | | Sheep. | | | Calf. | | | |
|--------------------|-------------|------|------|--------|------|------|-------|------|------|----|
| | oz. | drs. | grs. | oz. | drs. | grs. | oz. | drs. | grs. | |
| Solid extract | | 7 | 8 | 1 | 3 | 16 | 1 | 1 | 47 | |
| Humidity or phlegm | 11 | 6 | 64 | 11 | 5 | 32 | 11 | 6 | 44 | |
| Dry fibres | | 3 | 2 | 0 | 2 | 7 | 24 | 2 | 7 | 32 |
| | <hr/> | | | <hr/> | | | <hr/> | | | |
| | 16 or 1 lb. | | | Do. | | | Do. | | | |

The muscles of animals are composed of a parenchymatous and a cellular part, in which different humours are contained, partly in a conerete, and partly in a fluid state. These humours consist, 1. Of a red and white albuminous fluid. 2. Of a gelatinous mucilage. 3. Of a mild oil of the nature of fat. 4. Of a peculiar extractive substance. 5. Of a saline matter, the nature of which is very little known.

The analysis of the whole substance of the flesh, which affords, by distillation on the water bath, a vapid water, an alkaline phlegm, an empyreumatic oil, and carbonat of ammonia, and which leaves a coal from which a little fixed alkali and muriat of potash or soda may be extracted by incineration, affords no exact knowledge of the nature of the different principles; hence it is necessary

to have recourse to means, by which these substances may be extracted without obliging them to undergo a change of composition, and which afford an opportunity of examining them separately.

To obtain and separate these different substances, Thouvenel. Thouvenel made use of a press by which the fluid parts were squeezed out of the muscle; he then employed the action of fire to coagulate the albuminous part, and obtained the salt by evaporation; of water, to dissolve and separate the gelatinous mucilage, the salt, and extract; and of alcohol, to get the two last principles without the jelly. It is, however, very difficult to separate all these different matters exactly, as they are all soluble in water, and because the alcohol dissolves at the same time the saponaceous extract and a part of the salt. Fourcroy has therefore given a different process.

Thouvenel found, from his experiments upon different sorts of flesh, that,

1st. The *flesh* of the *ox* contained about three times it's Flesh of the weight of water and $\frac{1}{2}$ of dry extract, which on deduct- ox. ing the water, gives a proportion of one to four between the extractive matter and parenchymatous sponge; but for this conclusion it is necessary to exhaust the flesh by repeated decoctions, for in the ordinary preparations of this kind, scarcely the half of this product is obtained, since water dissolves a less quantity of the mucous matter of the parenchyma; so that one pound of flesh boiled four or five hours in twelve ounces of water affords commonly five or six drachms of dry residuum, *i. e.* dried as much as possible by a heat that is gentle and incapable of changing it's texture.

2d. The flesh of the *calf* is more aqueous and mucous Calf. than that of the ox. The large quantity of residue from it's evaporated decoction arises principally from it's parenchyma being more soluble in water. It is the

fanie in all young animals. The chicken gives more extract than the cock. They also give more than the ox and calf. But this arises in part from the bones of the first being admitted into these decoctions, as it is well known these substances give up to water a larger quantity of mucous matter than the fibrous part; thus stag's horn gives more than one fourth of it's weight; bone of the ox somewhat less, being older, more compact, and charged with offcous earth.

Turtle.

3d. The *land* and *water* turtles contain a little more matter soluble in water than the flesh of the ox or calf, but this arises from the offcous, cartilaginous, and ligamentous parts forming a part in the common preparation of boiled turtles; hence, Thouvenel found that one pound of turtle used in the common way, and exhausted by repeated decoctions, afforded more than ten drachms of residue, whilst the pure flesh gave scarcely one ounce in the pound; but the decoction placed on the *baln. mar.* for four hours, as is commonly done, gives a still less product; so that eight ounces of turtle in 20 ounces of water afforded 24 ounces of broth, and the grounds being expressed, half an ounce of dry extract was got by evaporation. Hence common broths from turtle only contain two drachms of mucous residue, whilst those from veal, chicken, and mutton, contain at least from five to six drachms.

Snail.

4th. *Snails*, separated from their shell by means of warm water, afford on decoction with an equal quantity of water on a *baln. mar.* about two drachms of extract less in the pound than the turtle, which places them nearly in the proportion of the before mentioned flesh, or between the ox and calf, with respect to the quantity of soluble matter.

Frogs, &c.

5. *Frogs, crawfish, and vipers*, deprived of their envelopes, intestines, and extremities, and then chopped, af-

ford, on being exhausted by decoction, nearly the same quantity of extractive matter as the other animals; *i. e.* about $\frac{1}{2}$ of their weight. But this proportion is not the same in the common preparation of these broths, for these last only then afford 4 or $4\frac{1}{2}$ drachms of residue per pound.

6th. The texture of *fish* being in general more tender Fish. and less fibrous than that of land animals, they ought to afford by decoction a greater quantity of soluble matter than the second. Experience, however, proves the contrary, at least with respect to fresh water fish, those of salt water affording more. This difference, according to Thouvenel, arises principally from the more or less glairy state, and the more or less concrescibility of the mucus of all aquatic animals, which causes their parenchyma to be more difficultly exhausted on decoction, and the extract more difficult to exsiccate, being more glutinous and gluey; and lastly, this dried glue to be more insoluble in water.

Such is the manner in which Thouvenel has examined the muscular substance of different animals, a memoir of which got the prize of the Academy of Bordeaux in 1778.

The process, which according to Fourcroy succeeds the best, is first to wash the flesh in cold water, which takes away the colouring part with a portion of the salt; then to digest the residuum of this lotion in alcohol, which dissolves the extractive matter and a portion of the salt; afterward, the flesh thus treated is to be boiled in water, which dissolves the gelatinous part and takes up, likewise, the portions of extract and of salt that had escaped the action of the former menstrua. The first water which was employed cold, is then to be gently evaporated, the albuminous part coagulates and is separated by the filter, and the slow evaporation of the fil-

Fourcroy's
experiments
and obser-
tions.

tered liquor affords the saline matter. By evaporating the alcohol in the same manner, the colouring extractive matter is obtained; and the decoction furnishes the jelly and the fat oil which swims upon its surface, and becomes concrete on cooling. After the extraction of the different substances, there remains nothing but the fibrous part, which is white, insipid, and insoluble in water; on burning it contracts; affords much ammonia, and a very fetid oil by distillation; and a large quantity of azot gas is expelled from it by the nitric acid; hence, it has all the characters of the fibrous part of the blood or of fibrin. To have a perfect knowledge, therefore, of the nature of the flesh of animals, it only remains to examine the properties of each of the substances of which it is composed.

The albuminous part is similar to that of the blood, and it is this matter which, on coagulating by the heat of the water in which meat is boiled, produces the scum which is carefully taken off. This scum is of a dirty brown red colour, the red being changed by the heat of ebullition. The gelatin which is extracted is the cause of the flesh of young animals, after having been boiled and become cool, taking the form of a tremulous mass or jelly, as it contains a larger proportion of this principle than the flesh of old animals; it is common gelatin. The oil which forms itself into flat and circular drops, swims upon the surface of boiled meat soups, and becomes solid or concrete on cooling, is similar to other animal oils. These three parts are consequently well known, and there only remains to examine the extractive matter, and the salts which are also obtained in the analysis of the muscles.

The substance called by Thouvenel *mucous extractive matter*, is soluble in water and in alcohol, it has an evident savour which jelly has not. In a concentrated state

it has an acid and bitter taste, and a peculiar aromatic odour which the fire develops; it is this matter that colours broths and gives them their agreeable flavour and odour. When they are too much evaporated, or a large quantity of meat is boiled in a small quantity of water, it is this that gives them their more or less strong and somewhat acrid taste and deep colour; lastly, the action of the fire extricates and heightens the flavour of this extractive matter even so as to give it the taste of sugar or barley sugar, as is observed on the surface of roast meat, which is commonly called the *brown*. If the properties of this extractive matter be examined when evaporated to a dry consistence, its flavour is found austere, bitter, and saline; placed on a live coal, it swells and liquifies, exhaling a penetrating acid odour, resembling that of burnt sugar; exposed to the air it becomes deliquescent, and a saline efflorescence takes place on its surface; it becomes sour, and putrefies on exposure to a warm air, if diluted with a certain quantity of water; and lastly, it is soluble in alcohol. All these characters appear to Fourcroy to prove, that this substance has a near relation to the soapy extracts and the saccharine matter of vegetables.

Since this chemist gave his opinion of the nature of this substance, Berthollet has discovered a peculiar acid in animal substances, which appears to form the characters of the matter in question, for according to Berthollet, this acid which he calls the zoonic acid, (*vide acids*) has an odour which resembles that of flesh whilst roasting, and it has an austere taste.

As to the salt which crystallizes during the slow evaporation of the decoction of flesh, its nature at present is but imperfectly understood.

Thouvenel obtained it in the form of down or of deformed crystals. He took it to be a neutral salt formed

of potash, and an acid resembling the phosphoric acid in frugivorous quadrupeds, and muriatic acid in carnivorous reptiles. Although this salt may be looked upon as unknown until further examined, Fourcroy thinks it very probable that it is the phosphat of soda and ammonia, and that there is even a mixture of phosphat of lime, as these salts are indicated, and even with an excess of acid, as is the case in urine, by means of lime water and ammonia, which form white precipitates on being added to broths, and by the nitric solution of mercury, which produces a rose coloured precipitate.

To these parts may be added that which is the most abundant in muscular flesh, and which constitutes its real character, viz. the fibrous part, the characters of which are: 1st, to be insoluble in water; 2d, to afford more azot gas by the nitric acid than any other substance, and to give afterward the oxalic and malic acids; 3d, to putrefy easily when moistened, and afford on distillation a large quantity of carbonat of ammonia. It is the same as that of the blood. From this fact, Fourcroy is of opinion, that the muscular organ is the reservoir in which the action of the vital powers deposits the fibrous matter of the blood, which, as before observed, contains it in large quantity, and that by repose it there becomes concrete, forming the basis of that animal property called muscular irritability.

Fourcroy obtained, on distilling four ounces of ox and calf's flesh on the baln. mar.

| | Ox flesh. | | | Calf's flesh. | | |
|--------------------|-----------|------|------|---------------|------|------|
| | oz. | drs. | grs. | oz. | drs. | grs. |
| Of fluid | 2 | 6 | 36 | 2 | 6 | 54 |
| Dry residuum | 1 | 1 | 36 | 1 | 1 | 28 |
| | <hr/> | | | <hr/> | | |
| | 4 | 0 | 0 | 4 | 0 | 0 |
| | <hr/> | | | <hr/> | | |

| | Ox flesh. | | | Calf's flesh. | | |
|-----------------------------|-----------|------|------|---------------|------|------|
| | oz. | drs. | grs. | oz. | grs. | drs. |
| Another portion gave out | | | | | | |
| of watery extract. (a.) | 0 | 1 | 56 | 0 | 2 | 30 |
| A fluid transmitted in b.m. | 2 | 6 | 36 | 2 | 6 | 54 |
| Remaining phlegm | 0 | 1 | 16 | 0 | 0 | 52 |
| dry fibres (b.) | 0 | 6 | 36 | 0 | 5 | 62 |
| | <hr/> | | | <hr/> | | |
| | 4 | 0 | 0 | 4 | 0 | 0 |
| | <hr/> | | | <hr/> | | |

(a.) Chemically examined

| | | | | | | | |
|-----------------------------|-------|---|----|---|-------|---|----|
| gave of fal. volat. | 0 | 1 | 2 | } | | | |
| Oil and spirit | 0 | 0 | 38 | | 0 | 1 | 12 |
| Carbon | 0 | 0 | 6 | | 0 | 1 | 0 |
| Left | 0 | 0 | 10 | | 0 | 0 | 18 |
| | <hr/> | | | | <hr/> | | |
| | 0 | 1 | 56 | | 0 | 2 | 30 |
| | <hr/> | | | | <hr/> | | |

| | | | | | | | |
|-----------------------------|-------|---|----|--|-------|---|----|
| (b.) Gave out of fal volat. | 0 | 2 | 0 | | 0 | 0 | 64 |
| Spirit volat. | 0 | 0 | 36 | | 0 | 1 | 37 |
| Carbon | 0 | 1 | 40 | | 0 | 2 | 18 |
| Left | 0 | 2 | 12 | | 0 | 0 | 13 |
| | <hr/> | | | | <hr/> | | |
| | 0 | 6 | 36 | | 0 | 5 | 12 |
| | <hr/> | | | | <hr/> | | |

Some experiments on the muscular fibre have been made by Hatchett, particularly upon that of *beef*. In order to separate the liquid albuminous part, or lymph, as much as possible, a quantity of lean muscle of ox beef was cut into small thin pieces, then macerated during fifteen days in cold water, and afterward subjected to pressure each day, when the water was changed. The weather was very cold, and the maceration continued to the end of the 15th day without any sign of putrefcency.

Hatchett's
experi-
ments on
beef.

The shreds of muscle (amounting to about three pounds) were then boiled with about six quarts of water, during five hours; and the water being changed, the same was repeated every day during the course of three weeks; at the end of which, the water afforded only slight signs of gelatin, when infusion of oak bark, or nitro-muriat of tin was added. After this, the fibrous part was well pressed and dried by the heat of a water bath.

Some of the muscular fibre thus prepared was steeped in nitric acid, diluted with three measures of water during fifteen days. The acid acquired a yellow tinge, and possessed all the properties of the nitric solutions of albumen.

The fibre which had been thus steeped in the acid was (when washed) dissolved by boiling water, and by evaporation became a gelatinous mass; which being again dissolved in boiling water, was precipitated by infusion of oak bark, and more slowly by nitro-muriat of tin, like albuminous substances when treated in a similar manner. When the fibre which had been steeped in the acid was immersed in ammonia, it was not completely dissolved, but afforded a residuum. The greater part, however, was dissolved, and formed a deep orange or yellowish brown solution, similar in properties to that of albumen. (*vide* white of egg.) When boiled with lixivium of caustic potash, this muscular fibre was completely dissolved, ammonia was discharged, and animal soap formed; which being diluted with water, and saturated with muriatic acid, yielded a precipitate similar to that obtained from animal soap, except that it sooner became hard and soapy when exposed to the air.

Muscular fibre prepared by long maceration, and subsequent boiling, with frequent change of water, so as to be nearly deprived of all its gelatinous part, is not easily

brought into the putrid state. A small quantity was kept moistened with water during April, in the course of which time it acquired a musty but not a putrid smell, neither were the fibres reduced to a pulpy mass; a portion of it was kept two months under water, but it neither became putrid nor was converted into that fatty substance obtained from recent muscle. Hence Hatchett is of opinion, that the readiness with which muscle becomes putrid is principally owing to the gelatin, which is mixed with it in large proportion, and which, with the natural quantity of moisture, is requisite to give the fibre a proper degree of toughness and flexibility.

The residuum afforded by muscular fibre which had been long steeped in dilute nitric acid, and afterward immersed in ammonia, consisted principally of fat, mixed with a small portion of the fibre which had not been sufficiently acted upon by the acid, and little or no earthy matter was thus obtained. But when the prepared muscular fibre was dissolved in boiling nitric acid, a complete solution resembling that of albumen in its general properties was formed, and some fat floated in drops at the top of the liquor. Ammonia was then added, so as to supersaturate the acid, and produced the same effects as on the nitric solutions of albumen, excepting that a copious white precipitate was obtained. This precipitate, while moist, was agitated with a quantity of acetic acid, which dissolved and separated a small portion of phosphate of lime; but the remainder, and by much the greatest part of this precipitate was scarcely attacked, even when the acid was boiled.

When exposed to a red heat, it became dark gray, and then nearly white; after which it was in the state of carbonate of lime.

Another part was dissolved in nitric acid, and lime was precipitated by carbonate of soda. The slight excess of

the latter was then saturated by acetous acid, and the whole was boiled to expel the carbonic acid ; after which the liquor from it's effects on solutions of lime, barytes, &c. evidently contained oxalic acid in solution ; the precipitate was therefore oxalat of lime mixed with a very small quantity of phosphat of lime ; 200 grains of the dry muscular fibre, dissolved and boiled with nitric acid, afforded 17 grains of this precipitate.

Although it is known that the gelatinous liquor obtained from muscle by boiling water, contains phosphats of soda and of lime ; yet Hatchett did not imagine the greater part of the latter could be so completely separated. He, therefore, in some measure, repeated the experiment on the *muscle of veal*, and found phosphats of soda and of lime in the liquor. But when the muscle was afterward dissolved in boiling nitric acid, and the solution saturated with ammonia ; he was surprised to find that although the same change in colour was produced as in all the former experiments, the liquor remained transparent, and even after several days, only a few scattered particles appeared at the bottom of the vessel.

Another experiment was made on the recent muscle of *mutton*, but this was immediately dissolved in nitric acid, without being previously boiled in water. The fat being separated, the solution was as before saturated with ammonia, and as usual became of a deep orange colour, or yellowish brown ; in a few hours also, a small quantity of a white precipitate subsided. This precipitate, however, was completely and readily soluble in acetous acid, and in every respect proved to be phosphat of lime.

This chemist observes, that the liquor from which the above precipitate was separated, as well as those afforded by the muscle of veal, by the prepared muscle of beef (as well as by the solutions of tortoiseshell and albumen) in boiling nitric acid, subsequently saturated with ammonia,

all contained a considerable portion of uncombined oxalic acid, which was separated by acetite of lime and of lead. But he did not find oxalic acid in the solutions formed by immersing the bodies, for a long time, in cold and dilute nitric acid; neither did he find oxalic acid in solutions made by dissolving the substances in boiling muriatic acid. It is evident, therefore, that the oxalic acid observed in the above experiments was a product of the operations, and not an educt of the substances.

Hatchett concludes from the experiments upon the above muscular substances, that they contain lime in various proportions, and in two different states, viz. carbonat and phosphat, and that the greater part of the latter is gradually separated, in conjunction with the gelatin, by means of boiling water. Not that phosphat of lime is an essential ingredient in gelatinous substances, on the contrary, isinglass, which is a perfectly gelatinous body, affords but a mere visible trace of it. The muscular fibre of beef appears to have been nearly deprived of its phosphat of lime, by the long-continued and repeated boiling in water to which it had been subjected; but still so large a quantity of lime remained, that when oxalic acid was formed by the action of the boiling nitric acid, it combined with the lime and formed an oxalat amounting to 19 grains from 200 grains of the dry muscular fibre, dissolved in nitric acid, and precipitated by ammonia. He does not know what quantity of lime was separated with the gelatin; but from the quantity of lime remaining, and which afterward combined with the oxalic acid, the muscle of beef must contain a considerable portion of earthy matter; and as by the experiment on the muscle of veal, scarcely any precipitate was obtained after it had been boiled, and as but a small portion of phosphat of lime was present in the gelatinous liquid, it appears, that in this muscle, the whole of the small portion of

His conclusions.

lime it contained was in the state of phosphat ; and this being nearly separated, there did not remain any part of uncombined lime or carbonat of lime, which by uniting with the oxalic-acid (subsequently produced) would form an oxalat ; and as lime in the states of phosphat and carbonat is so much more abundant in the muscle of beef than in that of veal, it may be inferred that the earthy matter is more abundant in the coarse and rigid fibre of adult and aged animals, than in the tender fibre of young ones ; and this seems to be corroborated by the tendency to morbid ossification, so frequently observed in aged individuals of the human species. Five hundred grains of the dry prepared muscular fibre of beef, when distilled, left 108 grains of coal, which, by incineration, afforded 25,60 grains of earthy residuum ; the coal may therefore be estimated at 82,40 grains. The greatest part of these 25,60 grains was carbonat of lime mixed with some pure lime and a small portion of phosphat, and there can be no doubt but that the latter would have been more abundant, had it not been for the repeated boilings to which the muscular fibre had been subjected.

The recent muscles of veal and mutton were, with great difficulty, reduced to ashes ; for toward the end of the process, the ashes and remaining coal became coated and glazed with saline matter, which appeared to be soda, partly in the state of phosphat.

Component
parts of
flesh

It appears, therefore, from the experiments already mentioned, that muscle or flesh consists of albumen, gelatin, fibrin, the phosphats of soda and of lime, muriat of soda, the zoonic acid, and iron ; but a more exact analysis is necessary to ascertain it's component parts with precision and certainty.

LIVER.

THE human liver has been examined by Fourcroy, but it was in a state of decomposition or putrefaction. Vauquelin, who has already rendered himself so highly eminent in the analysis of animal substances, has given a detailed account of that of the liver of the skate. Liver of the skate examined by Vauquelin.

It is well known to anatomists, that the liver of this fish (*raya batis*, L.) is very voluminous when compared to the other viscera, such as the heart and lungs, that its structure and texture are very delicate and tender, and that externally its appearance is fatty and oleaginous. It is of a gray colour, and when fresh has a rosy tinge, but this varies in different livers. Its flavour is saline and oily; its odour resembles that of mud, and is somewhat analogous to what arises from the filth of fish-markets. When boiled in water, it produces a great quantity of oil, which remains fluid at the ordinary temperature of the atmosphere. A piece of this liver produced by expression, after boiling, a slightly yellow coloured oil, that remained liquid at 10°.—When triturated with cold water in a mortar, it formed a white emulsion resembling milk, and in a few hours Vauquelin observed, that a yellowish cream arose to the surface, which appears to have been a portion of oil with a small part of the parenchyma. This emulsion was decomposed by the weakest acids, and small grumous parts separated from the clear liquor and arose to the top, as takes place in the decomposition of soaps by acids. This cream, on being agitated some time in a marble mortar, afforded no butter, but an oil much thinner than that extracted by heat. The parenchymatous and albuminous parts, which were coagulated, became brown in the air. The solution changed paper coloured by mallow to a green, which

this chemist attributes to an incipient putrefaction. Four ounces of this liquor bruised, and exposed to a gentle heat till no more vapours arose, afforded by expression one drachm seven grains of oil, the remainder weighed four drachms thirty-six grains; this last quantity of parenchyma, when incinerated, gave eight grains of a semi-fused white matter, which adhered slightly to the sides of the crucible. On adding muriatic acid to this matter, a sulphureous vapour was disengaged, and the liquor soon changed to a slight yellow colour, but there was no effervescence on the addition of lime-water; it appeared from the precipitation, that the ashes contained phosphat of lime.

Oxygenated muriatic acid being poured upon two drachms of this oil, until it ceased to give an odour, *i. e.* until saturated with oxygen and not decomposed, the oil became white as fat, and of the consistence of wax that has been kept between the fingers for some time. These experiments prove, according to this chemist, that the liver of the ray contains more than half its weight of oil already formed, and as to the conclusion to be drawn from it, *vide* article BILE.

Elémens d'Histoire Naturelle et de Chémie, 4. edit. par M. Fourcroy. t. 4. p. 431. 1791.—Encyc. Méth. Méd. t. 4. p. 573. chair des animaux.—Examen Chimique du Foie de Raie, par M. Vauquelin. An. de Ch. tom. 10. p. 193.—Hatchett's Expts. Phil. Transf. 1800.

WHITE PARTS.

BRAIN.

THE opinions with respect to the composition of this ^{Brain} organ have been chiefly confined to it's supposed oily nature, whilst others have denied it to possess any such property. Plato compared the brain to marrow, because like that substance it is soft and enclosed in an osseous envelop. Hippocrates, on the contrary, would not allow it to contain any thing that resembled fat. Aristotle was of opinion, that it was of a fatty nature in man and quadrupeds, and in the cetaceous class he had no doubt of it. This was again denied by more modern writers, and again asserted by Bartholin and Diemerbroeck; and as a ^{Ancient opinions.} proof in it's favour, they announced it's fatty touch, and it's inclination to liquefy or melt rather than run. Lewenhoeck, on examining the cortical part of the brain of a bird, thought it was formed of small vessels, and of a species of vitreous humour similar to fat. Afterward, chemical analysis came to support that opinion, and Lemery in particular, on submitting the brain to distillation, obtained a large quantity of limpid phlegm, volatile alkali, and two kinds of oil; the one yellow, and of the consistence of butter; the other black, fetid, and as thick as pitch. Burrhus also examined it, and on submitting it to the action of a hot press, after having squeezed out about three-fourths of it's weight of an inodorous phlegm, extracted a very inflammable oil from it, which on cooling suddenly, took a concrete form. Thoureret has since made some experiments on this organ; for although it was known to possess oily properties, not only from

Examined
by Thouret.

what has been already mentioned, but from it's having been found perfectly preserved for even fifty or eighty years from putrefaction, appearing like a fat or oily fluid matter, as we are informed by Faber and Herbinus; and although the solubility of the brain in aqueous fluids was known to anatomists, yet it's soapy character, or that it's oil was rendered miscible with water by means of an alkaline substance, was not even conjectured, until the experiments of this chemist pointed it out. It is from these Thouret concludes that the substance of the brain resembles that of the singular species of soap into which the greater part of the bodies was found to be transformed in the cemetery of the Innocents at Paris. It is like this last, formed of a more or less concrete and crystallized oily matter, very fusible, soluble in spirit of wine, and forming a species of real soap; and the only difference between them is, that in the bodies of the Innocents the oil is united with volatile alkali, whilst in the brain, potash is the alkaline substance; and he concludes, that it is from this oily or soapy nature, which appears to resemble spermaceti, that this organ is found to be so little susceptible of decomposition in the earth, provided it does not meet with any great degree of humidity, and that it is enabled to exist so long after all the other soft parts of the body are entirely decayed.

Fourcroy.

The experiments of Fourcroy appear to lead to a conclusion very different from those of the last mentioned chemist, they were made upon the fresh brains of the calf, the sheep, and the human animal, deprived of their sanguiferous vessels and membranes, interposed between the circumvolutions. These brains on being left to themselves for several days, at a temperature of twelve degrees, exhaled a very disagreeable odour, and sensibly changed blue paper green; and this before the production of any ammonia, although the green colour and detecta-

ble odour would seem to indicate an alkalescency. It partakes of this property with all other animal substances that contain mucilage, gelatin, or any white fibres susceptible of passing into the same state by the action of heat. Some dried brain, on being boiled with alcohol, formed a sort of glutinous paste, of a deep colour, ductile, and when pressed by the fingers, capable of being lengthened all ways. It does not melt in the heat of boiling water, but only becomes softer; when exposed to a higher temperature, it appears inclined to liquefy, it's colour becomes deeper, and of a darkish yellow; there arises an empyreumatic ammoniacal smoke, and the heat is increased; there remaining only a coal.

Fourcroy observes, that it is this substance that Thouret has not hesitated to compare to spermaceti, to the adipoceros matter of the bodies of the Innocents, and to the concrete oil extracted from biliary calculi by alcohol. These three substances have, however, no similarity with it in the eyes of the experienced chemist; for it is well known that a degree of heat from 36° to 32° , is sufficient to melt spermaceti and the adipoceros substance. As to the concrete biliary matter, it requires some degrees above boiling water to become fluid, and it does not emit during it's passage to that state any empyreumatic or ammoniacal vapour like that of the brain. These matters this chemist contends have therefore no resemblance, except a tendency to take a regular form on becoming fixed, and he looks upon this matter to be a substance *sui generis*, which differs from all other animal substances in the proportions of it's principles. Thouret relates, that Burrhus had expressed an oil from dried brain, concrescible by cold, which he compared to spermaceti; but Fourcroy is of opinion, that by the ordinary means employed to extract oils and fats, contained naturally in animal as well as vegetable substances, it is not to be got

Composi-
tion of the
brain.

from the brain, and that it is only by changing it's principles that some chemists have been able to obtain it. From the analysis of this organ, Fourcroy concludes, that besides this animal pulp *sui generis*, the brain is composed of the phosphats of ammonia, of lime, and of soda; that each is only in small proportion, that it contains no free alkali, and not an atom of potash, although admitted to exist in it by Thouret, and that of all animal substances the brain approaches the most in it's nature to that of the albumen of the blood.

Mémoire sur la Nature de la Substance du Cerveau, &c. par M. Thouret. Journal de Physique. Mai. p. 329, 1791.—Examen Chimique du Cerveau de plusieurs animaux, par A. F. Fourcroy, Annales de Chimie. tom. 16. p. 282.

SKIN.

OF the skins or hides of animals, there has only been skin. a slight examination of the epidermis of the human skin. According to Chaptal, the human epidermis is ^{Examined by Chaptal.} the most easily detached from the cutis of any, and it may be effected by the heat of water. The cutis then resembles softened cartilage in consistence. On continuing the boiling the skin is dissolved, but the hot water has no action on the epidermis.

Dilute nitric acid, according to Hatchett, has the same effect.

The epidermis is soluble in caustic alkalis; and by lime, although more slowly.

Alcohol digested a long time upon it with heat produced no effect.

From these circumstances Chaptal concludes, that there is some analogy between the exterior envelop of the human body, and that which acts as a cover to silk; and he draws some consequences that may be applied to the operations of tanning, thus:

1st. If a hide covered with its epidermis be plunged into an infusion of tan, this last can only penetrate by the fleshy side, the other being defended from it by the epidermis which is not susceptible of any combination with the tanning principle.

2d. When the epidermis has been taken off by the operation of depriving it of the hair, the tan is able to penetrate by both surfaces of the skin,

3d. The lime generally employed to take off the hair appears to act only by dissolving the epidermis. He found lime-water to have a stronger action than lime

undissolved, but that its effect ceased the moment the small quantity of lime held in solution became combined; hence, the necessity of renewing the lime-water to finish the operation.

Seguin on
tanning.

For the discovery of the true principles upon which the art of tanning hides is founded, we are indebted to Seguin. Before the investigation of this chemist, it was generally supposed that the tan in the tan pits had no other effect on the hides, than to harden and brace the fibres of the skin which had been relaxed by the preliminary operations; but the experiments of Seguin prove, that there exists in the tan a principle that is soluble in water, by which the tanning is effected; that this principle becomes afterward fixed in the hide in consequence of a particular combination between this principle and the skin, and that this combination produces a substance insoluble in water.

It is well known that if untanned leather be boiled in water it is soon dissolved by it, and this solution by being concentrated produces a jelly or size, which, by further evaporation and exsiccation in the air, becomes what is called glue.

Explanation
of the
process.

On examining the effect of a solution of tan upon a solution of glue, they are scarcely mixed before a white filamentous precipitate takes place, arising from the union of the gelatin with the tanning principle. This precipitate is insoluble both in hot and cold water, and acquires colour on exposure to light. This is the real explanation of the process of tanning. The solution of tan therefore acts upon the hides (from which glue is produced) in the same manner as it acts upon glue, and is what happens both in common tan pits and in the new method of tanning by Seguin, in both of which the solution of tan gradually penetrates the hide and combines with it, producing a gradual change of colour till the

hide is changed throughout, becoming of a marbled appearance resembling a nutmeg, and of a compact texture. From this it appears, that a precipitation also takes place in the action of tanning, although the hide is not dissolved, but merely swelled, so as to enable the solution of tan to penetrate it more easily.

This property which animal glue or gelatin has of being precipitated by a solution of the tanning principle, affords a method of discovering what substances may be useful in tanning. Nothing more is necessary than to make a solution or infusion of the vegetable substance, and this when mixed with a solution of glue will show whether it can be employed with advantage in tanning, by the greater or less quantity of precipitate produced.

Lime-water, likewise, according to the same chemist, offers an excellent means of discovering such substances. If, for instance, lime-water be added to a solution of tan, the mixture instantly produces a copious precipitate; and if a sufficient quantity of lime-water be added to neutralize the whole quantity of the tanning principle, the supernatant liquor, still coloured, will not form any precipitate with a solution of glue. In like manner, the liquor separated from a precipitation by the mixture of a solution of tan with one of glue, will not produce any precipitate with lime-water, if during the precipitation the tanning principle has been completely neutralized. This shows that Macbride's method of extracting tan by means of lime-water is defective; and that a loss of the tanning principle, takes place, in proportion to the quantity of it combined with the lime dissolved in the lime-water.

From the preceding account of the action of glue or of lime water upon a solution of tan, it follows, that every vegetable infusion, which affords a precipitate upon the addition of either of these reagents, must contain in a greater or less proportion the tanning principle. A decoction of Peruvian bark, for instance, when mixed with

lime-water, gives a precipitate which arises from the union of the lime and the tanning principle of the bark.

Tanning
matter.

The tanning principle appears to be a substance of a peculiar nature, which exists in astringent vegetables, and is not, as has been supposed, that acid called the gallic acid discovered by Scheele in galls, and found likewise in astringent vegetables, and said to have some effect in tanning. To the discovery of this tanning matter which Seguin found to be soluble in water, and which by uniting with the gelatin of the skin renders it an insoluble compound; it may be added, that when the water has extracted all the tanning matter from the tan, even to saturation, and has given it up to the gelatin of the hide; the same water may be used to extract more of the same matter from fresh tan; this facilitates the carriage of the tanning matter by reducing it to a small volume, or it may be converted into an extract. According to Proust, the aqueous solution of tan poured on a solution of glue, produces a magma possessing the elastic properties of the gluten of flour; that when left to itself it contracts, and on perfect exsiccation is brown and resembles glass in its fracture; that it is incapable of putrefaction; perfectly soluble in water; yields very little to alcohol, and by the means of hot water is capable of recovering its elastic properties. He likewise found, that the tanning liquor causes a precipitation in albuminous fluids, but the result is not a magma capable of the same transaction. Berthollet suspects that tanning cannot take place without the action of air, *i. e.* in closed vessels.

Having given some account of the principles upon which the art of tanning is founded, it will not be deviating from the subject to add a short description of the new chemical processes, which have been formed to accelerate the preparation of the skins, and the combination of the tanning matter or principle.

Previous to the experiments of Seguin, the process of tanning was an operation of much time and trouble, even years were necessary to bring the hide to a state of leather. The revolution this chemist has brought about in this art enables the tanner to complete his formerly arduous process in the short space of a few days, whilst the leather is superior in quality to that made after the old method.

New method of tanning according to Seguin.

The operations of this chemist consist, as in the former process of tanning, viz. in washing the hides, depriving them of the flesh and hair, raising or swelling them, and tanning properly so called; but the modifications and alterations he has made in these processes are very different. To this may be added that he operated upon 110 hides of oxen, cows, calves, horses, sheep, and goats, in the presence of Lelievre and Pelletier.

1st. *Washing and cleansing the hides.* In this operation no alteration is made by Seguin; he does not however throw them promiscuously into water as some tanners do, but stretches or extends them so as to permit the water to come into contact with every part. This precaution had already been recommended by others.

2d. *Taking off the hair.* With respect to shaving it off, which has always been looked upon as the most expeditious way, from some trials it was found by Seguin to be attended with disadvantages. Hides, it is well known, are covered with an epidermis, which is destroyed by the method of depriving them of their hair by lime; but as it still remains after the process of shaving, it is a great obstacle to the action of the tanning matter, by preventing its solution from penetrating the hide on its grain side; hence, a longer time is required for the process of tanning.

With respect to the employment of alkalis in taking it off, they are too expensive for common practice.

With respect to the method by means of lime, we are informed that some lime was first slacked; it was then put into a pit and mixed with a large proportion of water, and the whole was well stirred that the water might be well saturated with the lime; the hides were then suspended perpendicularly in the lime-water by strings attached to poles laid across the pit, and as it lost its strength, the lime at the bottom was often stirred in order to keep the water still saturated. The hair came off with great ease in this operation, after remaining about eight days in the pit.

By another method this chemist is in hopes of taking off the hair in two days. This consists in plunging the hides after being washed and cleansed in old tan water (which having been already used contains no tanning matter) mixed with a $\frac{5}{100}$ part, or sometimes with only $\frac{1}{100}$ part of sulphuric acid. He found that pieces of hides thus treated were deprived of their hair with great ease, and very completely raised or swelled. This chemist has so much confidence in this process, that he informed Lelievre and Pelletier, in whose presence it was performed, he would adopt it in a tan yard in preference to any other.

He is likewise of opinion that another method of taking off the hair might be advantageously practised in a tan yard, viz. by heat, produced by a stove kept constantly at 30° of Reaumur in which the hides are to be suspended; and it is observed by the above mentioned gentlemen, that if a little sulphur was burnt in the stove, so that the sulphureous acid gas arising might be equally diffused, it would greatly facilitate the process.

3d. *Swelling or raising the hides.* For this purpose large wooden tubs well joined together are filled with water, and a $\frac{1}{100}$ part of sulphuric acid added; into this mixture the hides are put, after having been previously well washed

and deprived of their hair. This quantity was decreased to $\frac{1}{1000}$. The hides began to swell after having remained a short time in this liquor, and in 48 hours the swelling is completed. They now acquire a yellow colour even in the interior part of their substance. In this state, according to Seguin, the process of swelling is finished: to determine this, one of the corners of the hide is to be cut, and if it be in a proper state, no white streak will appear in the middle; but through its whole substance the hide will have acquired a yellow colour, and a semi-transparent appearance. This method, it may be observed, is the same as that of Macbride, except that the proportion of sulphuric acid is much diminished.

According, however, to Seguin, this operation of the swelling of the hides may be dispensed with, since he has tanned them equally well without it; he even found the leather much less porous, and consequently less permeable to water.

4th. *Process of tanning according to Seguin.* Tanning, properly so called, is performed by this chemist, after a particular method. He does not lay the hides in a pit as is usually practised, but tans them by means of a solution of tan which he prepares in the following manner: He places several rows of casks upon stands elevated so much above the ground, that a vessel may be placed under each to receive the liquor which runs from them. These casks are filled with fresh tan; a certain quantity of water is then poured into the first of them, which, as it runs through the tan, extracts the soluble part, and as fast as it runs into the vessel below is taken out and poured into the second cask, and so on successively until the solution is sufficiently saturated; it may be brought to 10° or 12° of the areometer for salts. In order to exhaust the tan of the first casks, fresh water is poured upon it till it runs off perfectly clear, as the tan

is then completely deprived of it's soluble part. The liquors, as may be easily conceived, are carefully kept for future operations. It is proposed by this chemist, to make use in a tan yard of large wooden vats, for the preparation of the solution of tan.

It is particularly in the use of this solution that the method of Seguin consists. The quickness with which it acts is astonishing, and our surprise is excited that no person before him has attempted to put this method in practice in the large way.

As soon as the hides are taken out of the water impregnated with sulphuric acid, they are to be put into a weak solution of tan, where they are to be left one or two hours; they are then to be plunged into other solutions, more or less charged with this principle according to their strength, so that strong hides are tanned in six or eight days, others in fifteen, and others in twenty or twenty-five days. In placing the hides in these solutions some precautions are necessary.

Seguin proposes to have large vats which are to be filled with a solution of tan, the hides are then to be placed in them so as to be perpendicularly suspended about one inch distant from each other, as their touching would impede the action of the solution.

The hides, when taken out of the solution, must be dried with the usual precaution, *i. e.* so slowly as not to cause the hide to shrink on the flesh side. With respect to thinner hides, for the upper leather of shoes, he begins by washing and taking off the flesh in the manner described for strong sole leather; he then takes off the hair with clear lime-water; they do not undergo the operation of swelling, but are immediately put into weak solutions of tan, the strength of which he gradually increases, but without ever being brought to that degree of concentration used for tanning thick leather. Two,

three, or four days, are sufficient for tanning this thinner leather.

Leather which has not been sufficiently impregnated with the tanning matter, is generally known by a white streak in the middle of it's substance. This, however, was not perceptible in the hides tanned by Seguin in the presence of the above gentlemen. This method has likewise the advantage of affording an opportunity of examining from time to time the progress of the operation. For this purpose, nothing is necessary but to take a slip of the hide out of the vat, to cut off a corner of it, and the white streak, already mentioned, will appear more or less thick, until the tanning is completed.

The advantages of Seguin's method are, 1st. *It is much shorter.* The common method with lime requires, for strong sole leather, a year for the preliminary operations, and sometimes fifteen months more for the tanning operation in the pit. Sometimes it remains two years in the tan pits, it being pretended that the superiority of the leather is to be attributed to the great length of time the hides are left in them, so that they even sometimes remain two years and a half to carry the process to the greatest perfection. The duration of Seguin's method, is only about twenty days; in winter it is longer. 2d. *It is less laborious.* No manual labour is required, except in taking off the flesh and hair, for as soon as the hides are put into the solution of tan, they remain till the process is completed; whilst in the old way, there is a great deal of labour in taking them out of the pits, from time to time, to turn them. 3d. *It is less expensive.* There is one thing here to be observed; it is better only to prepare as much tanning solution as is necessary for present use, as the above gentlemen thought they observed a disposition in the solutions of tan to pass into the vinous fer-

Advantages
of the new
method.

mentation, which if the acetous should follow before the solution is exhausted, it would be an absolute loss of the tanning principle. Hence it is necessary to be watchful, especially in summer. 4th. *It produces leather at least of equal goodness.* To which may be added the important advantage of the extract of tan, which can be prepared in any forest on the spot, which from it's small volume and weight, when compared to oak bark, may be carried away with the greatest facility. It might be made in America, and transported to Europe, and also from other vegetables besides the oak. When used, it is only necessary to redissolve it in a proper quantity of water.

Biggin's
experiments
to ascertain
the quantity
of tan.

Since the bark of trees contains two principles, viz. the tanning, and the astringent, or in other words, tanning matter and the gallic acid, both of which are applied to the hide in the process of converting it into leather; it remained to investigate, whether or not the gallic acid was hurtful or useful; and for this purpose, Biggin made some experiments upon different barks, to ascertain the quantity of tan and gallic acid each bark contained, according to the process of Seguin.

His test to discover the tan, was a solution of one ounce of common glue in two pounds of boiling water, which consequently contained the matter of skin, as he calls it, in solution; and for a test of the gallic acid, he used a saturated solution of sulphat of iron.

For a preparation of bark, he divided one pound of each bark, in a pulverized state, into five parts, which he put into five different earthen vessels. To one part of this, he added two pounds of water, and infused them during one hour. This was then poured upon a second part, and this again on the third, and so on to the fifth. But as a certain portion of the infusion might remain attached to the wood of the bark, after decantation, he added a

third pound of water to the first part, and then followed up the infusion on the several parts, till the three pounds of water, or as much of them as could be separated from the bark, were united in the fifth vessel, from which he generally obtained about one pint of strong infusion of bark.

To a certain quantity of this infusion, he added a given measure of the solution of glue, which formed an immediate precipitation, to be separated by filtering paper. This, when dried, is the powder of leather, formed by an union of the matter of skin with the tanning principle, and, by saturating the infusion, the whole of the tan may be separated by precipitation.

To procure the gallic acid, he added to the pound of bark left in the earthen vessel, already deprived of the tan ^{The gallic acid.} by these *quick* infusions, a given quantity of water; but to get a strong infusion of this acid, a longer time (for instance 48 hours) is required. This infusion, when obtained pure (it being scarcely possible to separate them by this means, since a little of the acid always remains in the infusion of tan, and vice versa, unless the infusion of the gallic acid is very weak, and procured by a third or fourth operation) gives very little signs of the presence of tan, when tried by the solution of glue; but with the solution of sulphat of iron, a strong black colour is produced which differs in density according to the quality of the bark; and this may be further proved by boiling a skain of worsted in the dye, by which the gradations of colour may be perceptibly demonstrated.

Having thus obtained a point of comparison, and strictly attending to the specific gravity of the infusion, the quantity of precipitate of leather, and the density of colour produced by given quantities of one or the other test, the result will be found a comparative statement of

the respective powers of any bark or vegetable substance, which is sufficiently accurate for all commercial purposes; and the quantity of tan contained in them, when compared with that in the oak bark, the usual substance employed for the purpose of tanning, will determine the commercial utility of the bark.

For an accurate chemical analysis, he found the muriat of tin very convenient; for a solution of it being added to the infusion of bark, forms a precipitate with the tan, leaving the gallic acid suspended. This precipitate is of a fawn colour, and is composed of tan and oxydated tin. By these means, Biggin has been enabled to form a comparative scale of barks, which, however, he allows to be imperfect. In the following scale he has taken sumach as the most powerful; leaving, at the same time, a few degrees for a *supposed maximum of tanning principle*, which he reckons at 20.

| Bark of the | Gallic acid by colour. | Tanning princ. by the hydrometer. | Tan. princ. (in grains) from half a pint of infusion, and 1 oz. of so- lution of glue. | |
|--------------------|---------------------------|--------------------------------------|--|----|
| | | | | |
| Elm | 7 | 2.1 | ..... | 28 |
| Oak, cut in winter | 8 | 2.1 | ..... | 30 |
| Horse chefnut | 6 | 2.2 | ..... | 30 |
| Beach | 7 | 2.4 | ..... | 31 |
| Willow (boughs) | 8 | 2.4 | ..... | 31 |
| Elder | 4 | 3.0 | ..... | 41 |
| Plum tree | 8 | 4.0 | ..... | 58 |
| Willow trunk | 9 | 4.0 | ..... | 52 |
| Sycamore | 6 | 4.1 | ..... | 53 |
| Birch | 4 | 4.1 | ..... | 54 |
| Cherry tree | 8 | 4.2 | ..... | 59 |
| Sallow | 8 | 4.6 | ..... | 59 |

| | | | |
|-------------------------------------|----|------|-----|
| Mountain ash | 8 | 4.7 | 60 |
| Poplar | 9 | 6.0 | 76 |
| Hazel | 9 | 6.3 | 79 |
| Ash | 10 | 6.6 | 82 |
| Spanish chefnut .. | 10 | 9.0 | 98 |
| Smooth oak | 10 | 9.2 | 104 |
| Oak, cut in spring | 10 | 9.6 | 108 |
| Huntingdon, or Leicester willow ... | 10 | 10.1 | 109 |
| Sumach | 14 | 10.2 | 158 |

Biggin found that these barks preserved no respective proportion in the quantity of gallic acid and tanning principle contained in each, which he looks upon as an evidence of the distinctness of them, and may perhaps open a new field of saving oak bark in dying, since the willow, fallow, ash, and others, produce a very fine black. The quantities, likewise, of these two principles, do not differ in equal proportions between the winter and spring felled oaks, which may lead to a discrimination of the proper time for cutting, which is probably when the sap has completely filled and dilated that part of the vegetable intended for use. This will make a difference in the season of cutting oak, elm, and other trees, shrubs, &c. The leaves should be taken when at their full size, and then dried under cover; for as the tan is so soluble, and the substance that contains it, so thin, (the leaf) the dew is sufficient to dissolve it.

Finally, since the gallic acid does not seem to combine with the matter of skin, and as it's astringency will corrugate the surface, Biggin thinks it may be concluded, that it's presence in the art of tanning is not only useless but detrimental.

Sur l'Epiderme par le Cit. Chaptal. Annal. de Ch.

No. 77. p. 221. Proust sur le Principe Tannant. *ibid.* Mars, 1798, vol. 25, p. 228.—Account of the new Method of Tanning proposed by *Monf. Seguin*, by *Messrs. Lelievre & Pelletier*, *Repertory of Arts*, p. 272.—Vide also, *Mémoire, Trouver le Moyen de rendre le Cuir impermeable à l'Eau sans altérer ni sa force, ni sa souplesse, & sans en augmenter sensiblement le prix.* par le Cheval. de St. Réal. *Ann. de Chimie.* tom. 10, p. 44.—Experiments to determine the quantity of tanning principle and gallic acid contained in the bark of various trees, by *George Biggin, Esq.* *Nich. Journal.* No. 34, p. 392.

MEMBRANOUS, TENDINOUS, AND LIGAMEN- TOUS PARTS.

UNDER this head are to be comprehended all the fine membranes and cellular texture of the animal body; the white membranes that line the different cavities, as the pericardium, dura mater, pleura, &c. those that cover certain parts, as the periosteum, aponeurosis, &c. the different tendons that are attached to the muscles, and all others of a similar nature; and the ligaments that unite the joints, together with all others of similar appearance. Their properties.

These, when submitted to chemical analysis, appear to be all of a similar nature; but they have not at present been examined with such precision as to point out any minute differences that may exist between them, and which might appear to arise from the proportions of their component parts. They are insoluble in cold water; but by a gentle heat and after a certain time, they produce an acidity, perceptible both by the smell and taste. They readily pass to the putrid fermentation; but what characterizes them most is, that when these white membranous, tendinous, and ligamentous parts are put into boiling water, or are submitted to a boiling heat, they soon become soft, lose their texture, and are converted into a viscous, clammy, more or less thick liquid, which, on becoming cool, takes the form of a clear jelly, and which is of great use in the arts under the name of *glue*. When exposed to a gentle heat, without the intervention of water, they become dry, lose their toughness, are transparent, brittle, and easily break with a snapping between the fingers. By a stronger heat, they curl up and are con-

tracted, and, on continuing the heat, they melt, produce a fetid disagreeable smell, although not so empyreumatic as the more animalized parts; they swell and inflame, although the inflammation is somewhat difficult. The coal which remains, is light, and easily incinerated, whilst from their affording the usual products of animal substances in a small degree, they may be looked upon as but slightly animalized.

GLUE.

Glue.

AT the article *Gelatin*, it is observed, that it is particularly from the white parts of animals that substance is extracted; but as it was not intended, on discussing the nature of the component parts, to make any application of them to the arts, an account of the making of glue, and other circumstances attending it, were reserved for the present.

Glue has nearly all the properties of gelatin; the difference, according to Fourcroy, consisting only in the consistence. Gelatin has less viscosity and tenaciousness, being more particularly obtained from young animals; whilst glue, on the contrary, is only obtained from old animals, whose fibre is become drier and more strong.

Du Hamel.

According to du Hamel du Monceau, who has written, perhaps, the best work on the subject; glue was first principally prepared from a solution of the membranous, tendinous, and cartilaginous parts of animals; they were dried, and afterwards melted into tablets. It is, however, found, that all animal substances containing jelly, are capable of being made use of in the manufactory of glue; and du Hamel likewise informs us, that hartshorn and bones, after having been dissolved in Papin's digester, afforded a glue of great strength, but of a black colour.

That glue might be extracted from bones, we are in-

formed by Papin himself. In the edition of his works Papin. printed in 1782, it is said, that, by means of his digester, he had not only prepared a jelly from bones, but also from ivory, with which he had glued together some pieces of broken glass; and from experiments that have been since made upon them, it appears they contain it in a considerable quantity.

Spielman has added a good deal of information to that Spielman. found in Papin on this subject. According to this chemist, he has extracted glue, or dry jelly, not only from the bones, but all the hard parts of animals, simply by ebullition; that he procured more or less of it from the teeth of the wild boar, those of the sea horse, and likewise from the wood-louse, and the viper.

There are several sorts of glue made in Europe. The English glue is esteemed the best; it is of a brownish red colour. The Flanders is looked upon as next in point of goodness; it is whitish and transparent, whilst the most ordinary is made at Paris, and is black and opaque. The reason of this difference, according to Lewis, Lewis. arises from the Flemish and French employing bones and sinews, which do not afford so strong a glue as skins, from which the English manufacture their glue. According to this chemist, the method of preparation is, to steep and wash the parings or cutting of the hides in water; they are then boiled with fresh water till the liquor grows thick, when it is strained through baskets, suffered to settle, and afterwards further evaporated, till, on being poured into flat moulds, it unites, on cooling, into solid cakes, which are cut in pieces and dried upon a kind of net.

Grenet has been occupied for several years with the me- Grenet. lioration of this substance; he began by reading every thing already written on the subject; meditated very much on the qualities of the substances employed; and submitted to experiment those which had not been made use of,

and which appeared to him to be proper for it's preparation. Bones, however, produced it abundantly, and with great facility ; he first deprived them of their fat, and procured the jelly by simple ebullition ; and this, when converted into glue by drying, he found to be much superior to the French kind, and nearly equal in goodness to those of the best markets.

Parmenier. Parmenier, and Pelletier, who have also made experiments tending to the same end, obtained from 6lbs. of raspings of the button makers, 1lb. of glue, similar to the English sort. From the raspings of ivory the glue was more coloured, but equally as good. The raspings of horn they found to afford no glue.

As jellies acquire more or less colour by exposure to heat, on-being brought to a proper state of exsiccation, to procure glue as little coloured as possible, the less time it is exposed to heat the better ; hence, by using only a small quantity of water to extract the jelly, a less evaporation is necessary to concentrate it, so as to form that substance on cooling, and consequently a less exposure to the fire ; and if the jelly be afterwards cut into thin tablets or cakes, they will likewise be more easily dried. To following this plan, the Flanders glue is said to owe it's whiteness and transparency ; whereas by much exposure to heat, the parts become carbonized and black.

Glues differ from each other in their consistence, colour, flavour, odour, and solubility ; some of them dissolve very readily, when agitated in cold water, others are only soluble in boiling water ; the best ought to be transparent, of a yellow, inclining to a brown colour, without odour or flavour ; it should be perfectly soluble in water, forming a viscous fluid with it of an uniform consistence, and which on becoming dry, preserves equally, in every part, it's tenacity and transparency, and, in general, attains more solidity, colour, and viscidility, according to the age

and strength of the animal from which it has been extracted.

Clennel has given the most minute account of the making of glue, which was obtained during a visit to a manufactory in Southwark. He informs us, it is made from the parings of hides, horns of different kinds, pelts from furriers, and the hoofs and ears of horses, oxen, calves, sheep, &c. quantities of which are imported in addition to the home supply, by many of the great manufacturers of this article. These are first digested in lime-water to cleanse them, as far as it can, from any grease and dirt; they are then steeped in clean water, stirring them well from time to time; they are afterwards laid in a heap, and the superabundant water poured out; they are then boiled in a large brass caldron with clean water, skimming off the dirt as it rises, which is further cleansed by putting in, after the whole is dissolved, a little melted alum, or lime finely powdered, which, by their deterfive properties, still further purge it; the skimming is continued for some time, when the mass is strained through baskets and suffered to settle, that the remaining impurities, if any, may subside; it is then poured gently into the kettle again, and further evaporated, by boiling a second time, and skimming, until it becomes of a clear but darkish brown colour; when it is thought to be strong enough (which is known either by the length of time a certain quantity of water and materials have boiled, or by it's appearance during ebullition), it is poured into frames and moulds about six feet long, one broad, and two deep, where it hardens gradually as the heat decreases; out of these troughs or receivers, it is cut when cold by a spade, into square pieces or cakes, and each of these placed within a sort of wooden box, open in three divisions to the back; in this the glue, as yet soft, is taken to a table by women, where they divide it into three pieces, (when, by mistake,

they cut only two, that which is double the size is called a bishop, and thrown into the kettle again) with an instrument, not unlike a bow, having a brass wire for it's string; with this they stand behind the box, and cut by it's openings from front to back; the pieces thus cut, are taken out into the open air, and dried on a kind of coarse net work, fastened in moveable sheds of about four feet square, which are placed in rows in the gluemaker's field, (every one of which contains four or five rows of net work); when perfectly dry and hard it is fit for sale.

According to Clennel, that is thought the best glue which will swell considerably without melting, by three or four days immersion in cold water, and recover it's former dimensions and properties by drying. Glue that has got frost, or that looks thick and black, may be melted over again and refined, with a sufficient quantity added of fresh, to overcome any injury it may have sustained; but it is generally put into the kettle after what is in it has been purged in the second boiling. To know good from bad glue, the purchaser should hold it between his eye and the light, and if it appears of a strong dark brown colour, and free from cloudy or black spots, the article is good.

Size.

A superior and even colourless glue, called *fize*, is obtained from eel-skins, vellum, parchment, and some of the white kinds of leather, &c. but this is much too expensive for common use, and is only employed by those artificers whose work requires so delicate a substance, and where glue would be too gross. Such as use *fize* are the paper-maker, the linen manufacturer, the gilder of gold, polisher, and the painter in various colours, &c. For the same purpose the skins of the cat, rabbit, and hare, are employed.

Hatchett on
mucilage,
fize, and
glue.

Hatchett, in his experiments to investigate the composition of membrane, obtained various quantities of ge-

latin, and when the solutions of it were gradually reduced by evaporation, he had opportunities of frequently observing the various degrees of viscosity and tenacity which characterize mucilage, size, and glue. The difference in the viscosity and tenacity of the varieties of these substances, is, according to this chemist, evidently an inherent quality, and not caused by the degree of inspissation; for if this was the case, mucilage, size, and glue, when dry, he thinks, would be of equal quality, which is contrary to experience; for the varieties of glue are not of equal tenacity. Glue, made from certain parts of animals, such as the skin, being more tenacious and of better quality than that which is made in some places from feet and sinews. It differs also according to age; for the best and strongest glue is always obtained from the more aged animals, in whom the fibre is found to be most coarse and strong. But a longer continued boiling appears requisite to extract it, and the more viscid glues are obtained with greater difficulty than those of a less viscid quality, which may more properly be called size, and this difference is to be observed, when muscle is boiled with repeated and frequent changes of water. Gelatin thus obtained, whether in the state of mucilage, size, or glue, when completely dried, is affected by water according to its degree of viscosity; for when cold water is poured on dry mucilage, it dissolves it in a short time; but if cold water is poured on these varieties of gelatin, which when dissolved in a proper quantity of boiling water, would, by cooling, form jellies more or less stiff, it acts on them in different degrees, not so much by forming a complete solution, as by causing them to swell and become soft; so that when a cake of glue has been steeped three or four days in cold water, if it swell much without being dissolved, and, when taken out, recovers its original figure and hardness by drying, such glue is considered to be of the best quality.

The animal mucilage, which Hatchett employed, was obtained from the coroll. officin. as he found it to be pure, and not partly modified into gelatin or animal jelly; or in other words, the mucilage had not acquired the degree of viscosity requisite to form a gelatinous substance. The expression is not therefore to be understood as alluding to any essential difference in composition, but only to denote some variation in the degree of consistency; for the whole may be comprehended under the term gelatin, (vide art. Gelatin) of which mucilage may be regarded as one extreme, and the strongest and most viscid glue as the other.

As the qualities of gelatin are so various, so the properties of the substances in which it is present as a component part, are much influenced by it; and when, for example, skins of different animals are compared, he always found, that the most flexible skins afforded gelatin more easily, and of a less viscid quality, than those which were less flexible, and of a more horny consistency. The skin of the eel possesses great flexibility, and it affords gelatin very readily and in large proportion. The skin of the shark also, which is commonly used by cabinet makers to polish their work, was also soon dissolved, and formed a jelly like the former. The thin and tender epidermis or cuticle of these skins, although not soluble, was reduced into small particles by violent ebullition, and the spiculæ were also separated. The skins of the hare, rabbit, calf, ox, and rhinoceros, gave the same results, but gelatin from the hide of the rhinoceros, appeared the strongest and most viscid. In every one of the experiments, the true skin, or cutis, was principally affected (as Chaptal and Seguin have observed) by long boiling, but that of the rhinoceros far exceeded the others in difficult solubility. The cutis of these skins, when first boiled, swelled and appeared horny; it was then gradually dis-

solved ; but in the cutis of the rhinoceros a few filaments remained, which at length contracted and adhered to the cuticle. The cuticle of the different skins was softened, but not dissolved ; and as the cutis seems to be entirely formed of gelatin, so the cuticle appears to contain it, although in a small proportion. It is, however, necessary to it's flexibility, ; for when, after long boiling, the cuticle of the skins was dried, it became a brittle substance, which was easily reduced to powder.

Hair was much less affected than skin. The cartilages of the articulations are as completely soluble as the cutis, when long boiled with water ; but this is not the case with the other cartilages ; the other afforded little or none. It was the same with respect to quill shavings, and the horns of different animals, which were next subjected to experiment, and all afforded small quantities of gelatin, and the more flexible horns the greatest quantity, with the greatest ease, and, when deprived of it, and suffered to dry spontaneously, in the air, they become more rigid, and were easily broken. The horns were those of the ox, ram, goat, and chamois, which are perfectly distinct from the nature of stags or bucks horn ; for this is as different from the former, in chemical composition as in construction. Like bone, it affords much phosphat of lime, (vide bone) and like it, a large quantity of gelatin ; and it is observed by Hatchett, that phosphat of lime is generally accompanied by gelatin, as in stags horn, bone, ivory, &c. On the contrary, when carbonat of lime is the hardening substance, as in shells, madrepores, and millepores, no gelatin can be discovered ; for he has frequently digested the substances many days in boiling distilled water, after having reduced them to a coarse powder, that they might present a large surface, but never could discover the slightest vestige of gelatin. Hence the above horns are very different from the composition of

stags horn, and yield gradually, and with great difficulty, only a small quantity of gelatin.

Human nails and shavings of a hoof, long digested for several days, afforded like quill, only a slight cloud by nitro-muriat of tin. Tortoiseshell in small thin slips and shavings were affected in a similar manner.

Sponges and gorgoniæ, bladder and other membranes, afforded more or less gelatin.

He found the effects of the dilute nitric acid on the substances he subjected to experiment for the obtaining of glue, exactly kept pace with those of boiling water, of which he gives an instance of two pieces of skin recently taken from the ox, one of the pieces was boiled in water till the whole of the cutis was dissolved; after which the cuticle remained, although very feeble in texture, while the hair did not seem to have suffered any material alteration. The other piece was steeped in nitric acid, diluted with about four measures of distilled water. At the end of five days the cutis was dissolved, and the cuticle was become of a loose and feeble texture, but the hair had not suffered any apparent change excepting that of being slightly tinged with yellow. In both cases, therefore, the effects of boiling water, and of acid, were similar; and he found them to be more powerful on those parts which were the most gelatinous; and as water dissolves mucilage more speedily than size, and this last more speedily than strong viscid glue, so are the effects of very dilute nitric acid on the same substances.

In respect to æconomical purposes, all animal substances whatever, (exclusive of carbonat and phosphat of lime) may be converted into two substances of much utility, viz. glue and soap, with the additional advantage that those parts which would be rejected in making the one, are the most proper to prepare the other. The offensive smell of Chaptal's soap is considered as an objec-

tion, but this may be removed by exposing the soap for some time in flat vessels to the air; after which, it may be reduced to the proper degree of consistency by a second boiling.

ISINGLASS OR ICHTHYOCOLLA.

THIS is another fine species of glue, extracted from certain fish, very common in the Russian seas, and which are found on entering the large rivers. Hence the Wolga, Lyak, the Don, and Danube, afford large quantities, as well as the Caspian sea; they are even to be found in Siberia, known by the name of *kle* or *kla*, from being filled with the gluey matter. It is prepared in Moscow from the air bladders of the *sturgeon* and the *sterled*, which afford the most beautiful isinglass. After these, a fish called *ferrijouga* gives the next in quality; and lastly, the *belouga*. There is likewise another part of the fish situated near the back, to which it is attached, called the *vesiga*, which makes excellent isinglass, and this is said to be particularly the case with the fish *accipenser*. It is perhaps the *sounds* of the English.

Isinglass,
and the me-
thod of ma-
king it.

In general the fish of fresh water is preferred, affording an isinglass which is more delicate, more flexible, and exceedingly transparent; and there are numbers of small ones in the above rivers which excel in affording it in a superior degree.

The method of making the isinglass is, after the bladder has been extracted, it is washed with water to clean it of the blood, if any remains, but not otherwise. It is then cut lengthways, and the exterior membrane taken off, which is of a brown colour, whilst the other membrane, already mentioned, is so fine and white as to be taken from the fish with difficulty. They are first formed into rolls of the thickness of the finger, placing the fine membrane in the middle, and

are then suspended in the air to dry gradually. Isinglass is, however, converted into various shapes, as fancy directs. The best is made in the summer, as it is apt to have a disagreeable odour, if formed during the winter; at the same time, it diminishes in weight, and it's gelatinous qualities are affected. In order to be good, isinglass should be white, semitransparent, without odour, and perfectly dry. To dissolve it, it is reduced to small pieces by breaking it with a hammer, and then cut with scissars. In this state it may be dissolved in water, by a gentle heat, stirring it at times. It dissolves best, however, in spirit of wine, in which it particularly differs from common glue. The Russians have another kind of isinglass, in the making of which, heat is used; it comes from Gouriesgorodon, a small town on the Yaix, but it is of an amber yellow colour, and is not sold in commerce.

Besides the above mentioned parts of fish from which isinglass is made, a sort for the purposes of clarifying different wines and other liquors, is made from a variety of other fish, such as sea wolves, porpoises, sea cows, sharks, cuttle fish, whales, and all other fish without scales. Of these, the head, tail, bones, or cartilages, fins, skin, and indeed every part of the body, except the flesh and fat, or oil, are boiled in a large quantity of water, so as to prevent any access of smoke. It must be well skimmed in proportion as impurities arise. When all the viscous part is extracted, it is taken from the fire and left to repose, and afterward filtered through a linen cloth. The clear filtered liquor is exposed to heat a second time, until it is become so thick, that if a drop be placed on a plate, it fixes on cooling. It is then taken off the fire and left till it has acquired a certain consistence by cooling, when it is poured on tables of stone or marble, or other hard bodies, from which it may be easily separated, and at a proper time before all the heat is dissipated, it

is cut into tablets, and dried in the shade. This sort of isinglass, which, if properly made, is white and transparent, and on dissolving affords no sediment, is very serviceable in the clarifying of wine, fixing the matter in the composition of crayons, and for other purposes, such as the stiffening of silk and gauzes, the joining pieces of glass, or porcelane, making artificial pearls, and forming English sticking plaster. Isinglass is of all shades, from a perfect transparency to a black; but the worst pieces are large and yellowish, of a disagreeable odour, and opaque. A beautiful black may be given it by carbonizing it in a small degree.

According to Hatchett, 500 grains of isinglass, perfectly exsiccated, yielded 56 grains of coal, from which 1 grain and half of earthy residuum were obtained by incineration, which last being deducted, the proportion of coal appears to have been 54,50 grains. The 1,50 grs. were phosphat of soda, mixed with a very minute *proportion of phosphat of lime*. It's composed
of 2 parts.

Newmann's Chemistry—Rapport fait au Bureau de Consult. sur le Colle forte des os proposé, par M. Genet, par M. Parmentier, et Pelletier. an. dech. v. 13, p. 192.
—Macquer's Woerterbuch, art. *Leim*.—Encyclop. Méth. Arts et Métiers. t. 3, p. 60.—Nicholson's Journal, No. 8; Oct. an account of the art of making glue.

HARD PARTS.

THE principal use of these parts is to defend or support the animal, which, from their firm and fixed nature, they are capable of performing. They may be divided into bones, horn, shells, and zoophytes.

BONES.

Bones.

THESE are the hardest and most firm of all the parts of an animal, their texture is close and compact, more or less brittle, very little if in any degree flexible, and not capable of being softened by heat, like horn, so as to receive the impressions of different figures. When clean and in a healthy state, they are white; when diseased, yellowish, brown, or blackish, very porous, and often corroded.

Exposed to
a boiling
heat.

Bones, when deprived of their marrow (*vide fat*) and exposed to a boiling heat in water, afford a quantity of gelatin, and this is easier extracted if they be previously broken into small pieces or rasped (*vide glue*.)

Their distil-
lation.

By distillation in a retort, there arises an alkaline phlegm, a fetid empyreumatic oil, and much concrete volatile alkali; a black coal remains behind, which is very compact and very difficult to incinerate.

Calcination.

The ashes are white, and afford to cold water a small quantity of cretaceous soda; hot water afterward takes up a certain quantity of selenite; the residua of these lixivia is insoluble in water, and is the phosphat of lime discovered by Gahn of Stockholm, in 1769. Unless the fire be long continued and very strong, the large entire bones still remain black in the middle; and if calcined in a furnace, in the midst of charcoal, they remain lumi-

nous in the dark. By a very strong heat, they are semi-vitrified, and reduced into a very hard and white kind of porcelane.

Acids when diluted make them flexible and tough like leather, by decomposing the calcareous phosphat they contain, by which means they are deprived of their earth. It was by means of the vitriolic acid, that Gahn, first mentioned, made the discovery, and by this he separated the phosphoric acid. Kunckel and Beccher, who procured it from teeth, knew of it's existence in bones.

In 1777, phosphorus was prepared from bones by the means of this acid, by the chemists of Dijon, viz. Morveau, Marets, and Durande. For this purpose, bones of the ox, calf, sheep, &c. were placed in strata upon charcoal, in a furnace, and calcined, by which it was found that 41lb. of dried bones afforded nearly 24lb. perfectly calcined to whiteness. These were then pulverized in an iron mortar and sifted; 12lb. were taken and put into a stone-ware pan, common concentrated vitriolic acid was poured upon them until the effervescence ceased, and there was even a small excess; the mixture was then agitated, a sufficient quantity of water was added to favour the action of the acid, until it was become of the consistence of a clear soup, and it was then exposed for three hours to the heat of a sand bath. This last, however, may be dispensed with, by letting it stand at rest for several hours, until it proves thick.

Action of acids.

Vitriolic.

Preparation of phosphorus.

It is then diluted with a good deal of water, and filtered through cloth or paper, taking care to wash the residuum with warm water until it passes through tasteless, and no longer precipitates limewater, which proves that it no longer contains disengaged phosphoric acid. The filtered liquor being evaporated, gradually deposits a beautiful white silky substance, which is selenite, and must be separated by filtration, taking care to wash it with a suffi-

cient quantity of water to carry off any phosphoric acid that may adhere to it. The filtrations are repeated until the fluid deposits no more precipitate; it is then evaporated to the consistence of honey, when it appears with a brown and greasy aspect. If it be gradually heated in a crucible till it ceases to emit a sulphureous, and as it were an aromatic smell, and no longer boils, it acquires a semivitreous consistence, is of an acid flavour, and attracts humidity from the air. Exposed to a great degree of heat, it is fused into a transparent, hard, insipid, insoluble matter, without any acidity. The above quantity of bones afforded about 2 lb. 9 oz. of this semivitreous mass, independent of what adhered to the crucible.

This vitreous mass well pulverized, and mixed with one third it's weight of powdered charcoal, is put into an earthen retort, to which a receiver half filled with water, and pierced with a small aperture is adapted; the fire is then increased by degrees till the retort is heated to whiteness, at which time the phosphorus passes over in drops. The whole operation is from five to seven or eight hours, according to the quantity of matter distilled, and the heat the furnace is capable of giving. From the above quantity, 6 oz. 7 drachms of beautiful phosphorus were obtained. Fourcroy says, that from 6 lb. of bones, 20 ozs. or a little more of the vitriform residue is obtained, which afford about 3 oz. of phosphorus, and a few drachms of phosphorus half decomposed, which is nearly the same as the above. It is not necessary for the making of phosphorus to carry the operation further than till the matter has acquired the consistence of sirup, which may be conveniently performed in a copper vessel, and instead of a receiver, the neck of the retort may be just plunged simply in water contained in an open basin. Care must be taken that the neck of the retort be not plunged so deep as that the water may rise into the body

of the vessel when absorption takes place, but that the fluid in the basin, may, by it's fall, suffer air to enter; in this case a small quantity of the phosphorus in the neck of the retort, may be burnt, but the quantity lost is very inconsiderable.

Experiments with the vitriolic acid were likewise made by Nicolas, Pelletier, Bonvoisin, &c.

It has been seen that the osseous matter may be dissolved by the vitriolic acid. Some chemists have likewise employed the nitrous to extract the phosphoric acid. It was by this means that Scheele succeeded in preparing phosphorus so early as the year 1771, and he has been opposed to Gahn, although erroneously, as the first discoverer. He dissolved, by warm digestion, 4 lbs. of white calcined bones, coarsely pulverized, in 8 lbs. of nitrous acid, diluted with an equal quantity of water; to this he added four times the quantity more of water, which formed nitrat of lime; the salt remaining in solution, together with the disengaged phosphoric acid. On this mixture he poured diluted vitriolic acid, which seizing the lime from the nitrous acid, formed selenite. This salt being precipitated by it's insolubility, was separated by the filter after resting 24 hours, lixiviated, and the lye filtered and added to the first liquor. This was then evaporated, the selenite which was deposited separated, and distilled to the consistence of sirup; then levigated with two pounds of charcoal powder, exposed in a retort with a receiver adapted to it, half filled with water, to a strong fire, increased until phosphorescent vapours arose, and the phosphorus afterward clarified.

This method, employed by Scheele, was followed by Crell and Rouelle, who only made use of the vitriolic acid to precipitate the calcareous earth. This is an expensive method, but according to Morveau, has great advantages, for the nitrat of lime being more soluble than sele-

nite, there is no reason to fear that the salt which is produced should prevent the action of the menstruum; and since the vitriolic acid is only to decompose a liquid salt, there is certainty of not exceeding the quantity, which is a very important circumstance, this acid retaining selenite in solution; and all chemists agree, that the more selenite remains in the liquor, the less phosphorus is obtained. According to the same chemist, it is likewise very proper to *try the liquor* after it has been filtered, as Rouelle advises, by pouring into it a few drops of vitriolic acid, and of the nitrous solution of the osseous earth, as the first renders it turbid if there remains any of the nitrat of lime undecomposed, and the second discovers an excess of vitriolic acid.

Muriatic.

This acid was employed by Wiegleb for the solution of bones, looking upon it to be more advantageous for the precipitation of the selenite; he, however, allows that there was still some remaining, after the first distillation of the liquor; and it may be easily supposed that the muriat of lime must be more fixed than the nitrat of lime. Having separated the selenite as much as possible by the ordinary means, he added ammonia as a further precipitant, and distilled in a glass retort the precipitated liquor, which he calls ammoniacal phosphoric salt; by this means he obtained in the receiver some caustic volatile alkali, a portion of ammoniacal salt in the neck of the retort, and at the bottom some phosphoric acid, which he says had attacked the glass; he then dissolved it in warm water, evaporated the solution to dryness, melted it afterward in a crucible, poured out the matter which resembled a glass only in appearance, and which was very acid, and deliquesced in the air; and by this process he expected a very pure *phosphoric acid*, supposing that this acid passes to a glacial state only from the earths which remain in it,

The method followed by Wiegleb, it is evident, is incapable of increasing the product in the making of phosphorus; but according to the observation of Morveau, it may be of some use in the preparation of *phosphat of ammonia*. To obtain which, however, in it's pure state, he has himself proposed the following. Calcined bones are to be dissolved in diluted vitriolic acid, taking care to use less acid than is necessary to dissolve all the ossæous earth. It is then to be evaporated to separate the selenite; and if the operation be well managed, not only very little of this salt will remain in the liquor, but not an atom of vitriolic acid. This, however, may be tried, by adding a few drops of the nitrous solution of bones, which will cause no turbidness, if no acid remains. Volatile alkali is then to be added, even in it's caustic state, so as to saturate the phosphoric acid, which will form immediately an almost solid mass that must be diluted with water, in order to filter it, and the filtered liquor is a real solution of phosphat of ammonia, which, by spontaneous evaporation, affords very beautiful crystals of that salt, and which has been so laboriously searched for in urine. It is, however, mixed with a small quantity of phosphat of soda, which separates by effervescence in the open air. The calcareous phosphat, remaining on the filter, may be decomposed by the vitriolic acid for the making of phosphorus, so that nothing may be lost.

Method of
obtaining
phosphorus
by Mor-
veau.

The phosphoric acid has likewise been obtained from other bones besides those already mentioned. Bernard obtained it from fossil bones; likewise from the bones of the elephant, whale, porpoise, elk, ox, teeth of the sea-cow, the human species, and grinders of the elephant. From his experiments it appears, that all these bones afforded the same substances, and contained phosphoric acid in different proportions. The Marquis de Bouillon obtained a phosphoric glass from ivory, the head of a

A variety
of bones af-
fords it.

sturgeon, and Fontana from the bones of fishes. Calcinated bones generally afford one third of their weight of this acid; and Nicholas observes, that the bones of young animals do not contain it in such large quantity as those of old ones; and the same may be said respecting the quantity of earth to which it is united. Thus the bones of the foetus are said to contain about one third part of earth, in the adult nearly one half, whilst in old age it composes the greater part. On the contrary, the younger the animal, the greater is the proportion of gelatin in the bone. According to Accum, fish bones contain nearly one sixth more phosphoric acid than the bones of quadrupeds.

Action of
alkalis.

From the experiments of the academy of Dijon, carbonated alkalis decompose the phosphat of lime in bones. A small quantity of alkali is also used in bleaching them; for, when boiled in a large proportion of water, the alkali forms a soap with the fatty matter. But the best method

Smith's ex-
periment
on bleach-
ing of bones
by oxygen-
ated muri-
atic acid.

of bleaching bones is given by Mr. Smith of Bristol. Being struck with the effects of the bleaching liquor on cotton and linen, he applied it to the whitening of bones. Having in his possession a cranium lately prepared, perfectly clean and inodorous, but so brown as not to be worth preserving, he exposed it with the vertebræ of the neck to an oxygenated muriatic atmosphere; for which purpose he adapted a cork, with a stop-cock driven through it, to the aperture made for the candle, at the bottom of a common lamp-glass. For a retort he used a Florence flask, which contained one fourth of an ounce of black calx of manganese, mixed with half an ounce of muriatic acid, and a long bent tube of glass fixed into it's neck served to direct the product at pleasure.

The skull had been immersed for twelve hours in a weak caustic solution of potash; but he has not ascertained whether this is absolutely necessary. The lamp, which

contained these bones thus prepared, was placed in a large trough of water. The stop-cock at the end afforded the means of filling it with water by exhausting the column of air above. It now remained to dislodge the water, by placing the flame of a spirit lamp under the retort, and the extremity of the tube under the lamp glass. In a few minutes, the yellow oxygenated muriatic acid was evolved, and, as the water sunk, those bones exposed to it's influence, assumed the same appearance. This operation was continued till the glass was emptied; but it was found necessary to continue the process slowly, in order to recruit the air that had been absorbed by the preparation and water, demonstrated by the rising of this fluid. In six or eight hours the glass was removed, and the head, which was of a bright golden colour, was exposed to the open air and the rays of the sun. As it dried, it became paler, and covered with small shining crystals, which were washed off in rain water, and the bone was become so beautifully white as to exceed in appearance any thing he had seen before of the same kind. With old bones this process did not succeed so well as with recent; but even these, in some cases, were well bleached. The cranium being enclosed in a dark case, became rather diminished in it's whiteness, from the exclusion of the light; but this gentleman informs us, it still retains it's beauty, sufficiently to demonstrate the superiority of the process.

With respect to the other component parts of bones, some slight mention had been made of the presence of a little selenite; and, according to Proust, they are composed of mineral alkali, selenite, phosphoric lime, and a peculiar substance; but the phosphat of lime was supposed to be the principal ossifying matter in them.

A more perfect and satisfactory analysis has been made by Hatchett. He observes, that it is scarcely necessary to mention the usual effects of acids on bones when steeped

Their component parts according to Proust.

Hatchett's experiments on bones.

in them : for it is well known, that in every operation of this nature, the ossifying substance, which is principally phosphat of lime, is dissolved, and a cartilage or membrane of the figure of the original bone remains. With respect to the menstrua, precipitants, and mode of operation, the bones and teeth were subjected to the action of the acetous, or diluted nitric and muriatic acids. The dissolved portion was examined by carbonat of ammonia, or of potash, which precipitated the carbonat of lime, and the phosphat of lime was precipitated by pure or caustic ammonia. In experiments, where the quantity of the substance would permit, the phosphoric acid was also separated by nitric or sulphuric acid. The phosphoric acid, thus obtained, was proved, after concentration, by experiments well known to effect such purposes. As the principal object was to discover the most prominent character, this chemist did not attempt, in general, to ascertain, minutely, the proportions so much as the number and quality of their respective ingredients.

He found that the bones of fish, as those of the salmon, mackerel, brill, and skate, afforded phosphat of lime, and the only difference between them, and those of quadrupeds, &c. was, that the first appeared, in general, to contain more of the cartilaginous substance, relative to the phosphat of lime, than is commonly found in the last. The different bones also of the same fish were various in this respect, and the bones about the head of the skate only differed from cartilage, by containing a moderate proportion of phosphat of lime.

It is at present believed, that phosphat, with some sulphat of lime, constitutes the whole of the ossifying substance ; and he thinks it probable, that the formation of bone from cartilage depends on the phosphat of lime ; but whether this be the case or not, it is necessary to

mention a third substance that occurred in the course of his experiments.

When human bones or teeth, as well as those of quadrupeds and fish, whether recent or calcined, were exposed to the action of acids, an effervescence, although at times but feeble, was produced. This circumstance he did not at first particularly notice, but the following experiments excited his attention.

After the phosphat of lime had been precipitated from the solutions of various teeth and bones, by pure ammonia, he observed, that a second precipitate, much smaller in quantity, was obtained by the addition of carbonat of ammonia. This second precipitate dissolved in acids with much effervescence, during which, carbonic acid was disengaged, and selenite was formed by adding sulphuric acid. Moreover, the solution of this precipitate contained no phosphoric acid, nor did the liquor from which the precipitate had been separated, afford any trace of it.

This precipitate was therefore carbonat of lime; but still he was not certain that it existed as such, in the teeth and bones; and as sulphat of lime had been already proved by former chemists to exist in bones, he was desirous of ascertaining, whether the carbonat of lime he had obtained had been produced from the sulphat having been decomposed by the alkaline precipitate, or whether the greater part had not existed in the bones in the state of carbonat.

Each of the solutions in nitric acid afforded a precipitate with nitrat of barytes; but the quantity of sulphuric acid thus separated appeared by far too small to be capable of saturating the whole of the carbonat of lime obtained from an equal quantity of the solution. To prove, therefore, the presence of the carbonic acid, and

the consequent formation of the carbonat of lime, portions of the various teeth and bones were immersed in muriatic acid at separate times, and the gas produced was received in lime-water, by which it was speedily absorbed, and a proportionate quantity of carbonat of lime was obtained.

Teeth.

This chemist then examined the enamel of teeth. When a tooth, coated with enamel, is immersed in diluted nitric or muriatic acid, a feeble effervescence takes place, and the enamel is completely dissolved; so also is the bony part, but the cartilage of that part is left, retaining the shape of the tooth: or, if a tooth, in which the enamel is intermixed with the bony substance, be plunged into the acid, the enamel and the bony part are dissolved in the same manner as before, *i. e.* the enamel is completely taken up by the acid, while the tooth, like other bones, remains in a pulpy or cartilaginous state, having been deprived of the ossifying substance. Consequently, those parts, which were coated or penetrated by lines of enamel, are diminished in proportion to the thickness of the enamel which has been thus dissolved, but little or no diminution is observed in the tooth. This has been noticed by Hunter, who, speaking of enamel, says, “when soaked in a gentle acid, there appears no gristly or fleshy part with which the earthy part had been incorporated.” Hatchet has also observed, that when raspings of enamel are put into diluted nitric or muriatic acids, they are dissolved without any apparent residuum; but when raspings of tooth or bone are thus treated, portions of membrane or cartilage remain, corresponding to the size of the raspings. According to Fourcroy and Vauquelin, 100 parts of enamel of teeth contain 43.3 of lime, 29.67 of phosphoric acid, and 27.10 of gelatin and water.

Hatchet has also examined the fossil bones of Gibraltar,

as well as some *glossopetræ*, or shark's teeth. The latter Fossil bones and shark's teeth. afforded phosphat and carbonat of lime; but the last was visibly owing principally to the matter of the calcareous strata, which had enclosed these teeth, and which had insinuated itself into the cavities left by the decomposition of the original cartilaginous substance.

The bones of Gibraltar rock he found also to consist principally of phosphat of lime, and the cavities have been partly filled by the carbonat of lime, which cements them together.

Fossil bones resemble bones which, by combustion, have been deprived of their cartilaginous part; for they retain the figure of the original bone, without being bone in reality, one of the most essential parts having been taken away. Now such fossil or burnt bones can no more be regarded as bone, than charcoal can be considered as the vegetable of which it retains the figure and fibrous texture.

Bones, which keep their figure after combustion, resemble charcoal made from vegetables replete with fibre; and cartilaginous bones, which lose their shape from the same cause, may be compared to succulent plants, which are reduced in bulk and shape in a similar manner.

From these last experiments, this chemist doubts if bodies consisting of phosphat of lime, like bones, have concurred materially to form strata of lime-stone or chalk. As it appears improbable that phosphat is converted into carbonat of lime after these bodies have become extraneous fossils, he is of opinion that the destruction or decomposition of the cartilaginous parts of teeth and bones, in a fossil state, must have been the work of a very long period of time, unless accelerated by the action of some mineral principle: for, on putting the os humani of a man brought from Hythe in Kent, said to have been taken from a Saxon tomb, in muriatic acid, he found the

remaining cartilage nearly as complete as that of a recent bone. The difficult destructibility of substances of nearly a similar nature, appears also from the mining implements formed of horn, not unfrequently found in excavations of high antiquity.

Component
parts of
bones.

From these experiments it appears, that bones are not earthy matters, as they were formerly supposed; and that they are neither composed of calcareous earth and clay, as some chemists affirmed, nor of magnesia, as others were willing to imagine; but that they contain a certain quantity of gelatin, dispersed in small cavities, formed by the interval between the fibrous part which composes their texture; and, although they may appear to resemble earthy substances, from their insolubility and firmness, they are proved to be formed of two earthy neutral salts, a large quantity of phosphat of lime, a small proportion of sulphat of lime, and some carbonat of lime.

Ossification.

In the first origin of bones, the first part that is formed is a membrane or cartilage of the requisite figure which, when the subsequent secretion of the ossifying substance takes place, is penetrated by it, and more or less converted into the state of bone, the nature of which is more or less influenced by the greater or less predominance of the membranous or cartilaginous part, than by any other cause; for it is by means of it that the bone acquires its greater or less solidity; and, although the principal effects during ossification are produced by phosphat of lime, it appears, that the sulphat or carbonat of that earth is necessary; and, according to Hatchett, it is curious to observe, that as the carbonat of lime exceeds in quantity the phosphat in crustaceous marine animals, and in the eggshells of birds, so in bones it is vice versa; and he thinks, that when many accurate comparative analyses of bones have been made, some may be found composed only of phosphat of lime; and that thus, shells,

containing only carbonat of lime, and bones containing only phosphat, will form the two extremities of the chain. Thus the hard substances are by no means passive in the animal œconomy, being renewed and subject to disease, as well as the other parts, and they are considered by Fourcroy as real secretory organs, the office of which is to separate from the blood the peculiar saline substances, and more particularly the phosphat of lime, of which they are the reservoir, or place of deposition.

Hatchett, in a second paper read before the Royal Society, in London, has examined the substance of bones that remains after repeated boiling, or having been steeped in dilute acids. For when a bone or piece of ivory has, by long boiling in water, been deprived of a great part of it's gelatin, and is afterward steeped in a dilute acid, the ossifying substance, as already observed, is dissolved, and the cartilage remains, retaining the figure of the original bone; or if a similar bone or piece of ivory which has not been boiled, is steeped in a dilute acid, (especially nitric acid) the ossifying substance is dissolved; and at the same time, but more slowly, the gelatin is separated, and causes the liquor to become yellow, when the phosphat of lime is precipitated by ammonia. The cartilaginous substance that remains after the gelatin has been thus separated, is not easily soluble in dilute acids, for (according to it's texture) many weeks and even months may elapse before a small part is taken up; but in concentrated nitric acid, or in boiling dilute acid, it is readily dissolved. This substance, when dry, is semitransparent like horn, and more or less brittle, and when subjected to experiment, afforded the following results.

Further experiments
of Hatchett.

1. When distilled, a small portion of water, some carbonat of ammonia, a fetid empyreumatic oil, carbonated hydrogen gas, and prussic acid were obtained.

2. A spongy coal, of a gray metallic lustre, remained;

this, by incineration, afforded a very small residuum, which residuum (on examining the same substance in different bodies) was not always similar in quantity, even in portions of the same substance; for 500 grains of tortoiseshell, taken from different samples, afforded from one fourth of a grain to three grains of residuum, which consisted of phosphats of lime and soda; sometimes also a little carbonat of lime was present, but he does not consider these to be essential ingredients.

3. When boiled many days in distilled water, the substance was softened, and the water became slightly turbid with nitro-muriat of tin; but no effect was produced by the tanning principle.

4. Muriatic and sulphuric acids had little effect unless heated, and the same was the case with nitric acid, much diluted, (the nitric acid he employed was 1,38, and this was diluted with two, three, or four measures of distilled water) or in a state proper to extract and separate gelatin; but if the immersion in the dilute acid was continued during some weeks, the acid gradually acquired a yellow tinge, and when saturated with ammonia became of a deeper colour, without having it's transparency diluted.

5. The substance which had thus been long steeped in the acid was much softened, was become more transparent, and from being horny, was now more like a cartilaginous substance: when taken out of the acid, if it was immediately steeped in pure ammonia, it changed to a deep orange colour, inclining to blood red; it was gradually and silently dissolved without any residuum, and a deep orange or yellowish brown coloured liquor was formed.

6. Or when taken out of the acid, if it was first well washed in distilled water and then boiled, it was also dissolved, and formed a pale yellowish solution; this, by evaporation and cooling, became a jelly, which was

again soluble in boiling water, and was precipitated like gelatin by the tanning principle, and more slowly by nitro-muriat of tin.

7. If the nitric acid in which the substance was immersed was not sufficiently diluted, or if heat was applied, the whole was rapidly dissolved, with a considerable effervescence and discharge of nitrous gas.

8. This solution was yellow like the former, the colour being intense, in proportion to the quantity dissolved; and it was also changed to a deep orange or yellowish brown by the addition of ammonia, without depositing any precipitate, unless a large quantity had been dissolved.

9. The nitric solutions of this substance, when evaporated, afforded much the same appearances as those of gelatin, but the coal which remained was less spongy.

10. This substance was strongly distinguished from gelatin by the effects produced, when boiled with caustic fixed alkali, which formed with it an animal soap.

11. During the process, a considerable quantity of ammonia was discharged, and if the alkali was in excess, some coal was deposited.

12. When the animal soap was dissolved, diluted with distilled water, and filtrated, if an acid (such as the acetic or muriatic) was added, a copious precipitate was obtained, which was redissolved by an excess of acid.

13. This precipitate being collected upon a filter, appeared at first like a yellow or brownish viscid substance, which, when dry, was like a thick coat of varnish, or dried white of egg, and in like manner was brittle, and broke with a glossy fracture.

14. It burned like quill or tortoiseshell, leaving a spongy coal, and when distilled afforded similar products.

15. It was not readily soluble in dilute acids, and was acted upon by nitric acid and ammonia, like the sub-

stance from which it was obtained ; the properties also of it's solutions in nitric acid and ammonia were similar.

16. With caustic lixivium of potash, it readily combined, and again formed animal soap.

17. It was not quite so insoluble in boiling water as quill or tortoiseshell, and the water in which it had been boiled was not only made turbid by nitro-muriat of tin, but yielded a precipitate by oak bark after the manner of gelatin.

These experiments proved, that this precipitate was the same as the original substance from which it had been obtained, and that the only change it had suffered was that of being rendered rather more soluble in boiling water.

From these experiments it also appears, that this cartilaginous body was quite distinct from gelatin in chemical properties, and having compared them with some experiments on inspissated albumen, (white of egg) he found they corresponded in great measure.

He found this to be the predominant and essential part in the tissue or web of membrane, cartilage, sponge, the horny stems of gorgoniæ, horn, hair, feather, quill, hoof, nail, horny scale, crust and tortoiseshell, varying in the colour of the soaps it formed.

According to the experiments of Merat-Guillot, on the comparative proportions of the component parts of different bones, of which he employed 100 parts, exsiccating the products as much as possible, it appears that

Experiments of
Merat-
Guillot.

| | Gelatin. | Phosphat of lime. | Carbonat of lime. | Loss. |
|---|----------|----------------------|----------------------|-------|
| Human bones taken from the church-yard gave | 16 | 67 | 1.5 | 15.5 |
| Common dry human bones that had not been in the earth | 23 | 63 | 2 | 2 |

| | | | | |
|------------------------------|------|------|--------|-------|
| Bones of the ox | 3 | 93 | 2 | 2 |
| Calf | 25 | 51 | traces | 21 |
| Horfe | 9 | 67.5 | 1.25 | 22.25 |
| Teeth of the horfe | 12 | 85.5 | 0.25 | 2.25 |
| Elephant or ivory | 24 | 64 | 0.1 | 11.15 |
| Bones of the sheep | 16 | 70 | 0.5 | 13.5 |
| Elk | 1.5 | 90 | 1 | 7.5 |
| Stags horn | 27 | 57.5 | 1 | 14.5 |
| Bones of the pig | 17 | 52 | 1 | 30 |
| Hare | 9 | 85 | 1 | 5 |
| Hen | 6 | 72 | 1.5 | 20.5 |
| Egg shells | 3 | 2 | 72 | 23 |
| Bones of the pike | 12 | 64 | 1 | 23 |
| Carp | 6 | 45 | 0.5 | 48.5 |
| Viper | 21.5 | 60.5 | 0.5 | 17.5 |
| Lobster shell | 18 | 14 | 40 | 28 |
| Mother of pearl | 2.5 | 0 | 66 | 31.5 |
| Crabs eyes | 2 | 12 | 60 | 26 |
| Red coral | 0.5 | 0 | 53.5 | 46. |
| Jointed coralline | 7.5 | 0 | 49 | 43.5 |
| Bone of the cuttle fish | *8 | 0 | 68 | 24 |
| White coral | 1.5 | 0 | 50 | 48.5 |

With respect to the gelatin of the cuttle fish bones, this chemist thinks the product is not entirely composed of it, but that there is a portion which resembles in it's nature that which forms the *charpente* of the polypi, known under the name of the lithophytes.

Desirous of knowing whence arose the loss, he exposed 100 parts of crabs eyes to a strong heat, and they lost 22 parts; hence he thinks this loss may be attributed to the water in the gelatin; but the four remaining parts to a portion of gelatin found dissolved in the liquid used in the analysis, and to a small quantity of saline substance, which he did not examine. To make this analysis more complete, he intends to add to it that of

the bones of carnivorous animals, skeletons of insects, &c.

Diseases of bones.

In some diseases of the bones, particularly in rickets, it is well known that there is a want of the phosphat of lime, on which account the bones become soft, and cannot sustain the muscular action; this happens more particularly in infancy, and as the serum of milk is found by Fourcroy and Vauquelin to contain this earthy salt, a too small quantity of milk, or one that does not contain this salt in sufficient proportion, may produce or assist in producing this disease. Experiments have, therefore, been made where this salt is deficient, to apply it to the bones as a medicine, by means of the digestive canals, which has been found to succeed. Bonhomme informs us, that on giving the phosphat of lime to chickens, he found the bones acquired a greater degree of solidity and hardness, and their epiphyses were much less sensible than in those that were only fed in the usual way; and having given it as a medicine to patients attacked by rickets, it produced the most beneficial effects. The dose to an infant was half a drachm of the phosphats of soda and lime mixed together, to be taken twice a day. It may be useful in fracture where there is difficulty in the formation of callus, in dentition, &c. This che-

Phosphat of lime in milk, and it's use in ossification.

mist likewise informs us, on the subject of the phosphat of lime in milk, destined for nourishing the infant, that the nearer the milk is to the epoch of delivery, the more is the serosity found charged with this salt; on the contrary, the farther it is distant from birth, the more it loses of this substance, in proportion, whilst the other nutritive parts of which milk is composed increase in an inverse progression. This is easily accounted for, if it be considered that at the time of delivery a softening has been made in all the joints of the mother, consequently a relaxation in the cartilages which unite them, and that

the fractures of bones which occur at this time are slower in uniting than at other times. It is by such means that the humours which contribute the most to the formation of the fœtus, it's increase, and nutrition, carry in themselves the essential basis of solidity, and the elements of ossification; in short, it is only when the ossification is well pronounced, and the digestive organs of the child are sufficiently strong to effect this part of animalization, that this basis disappears in the maternal milk. On considering these facts, we shall be obliged to acknowledge the peculiar direction of nature, by which the phosphat of lime, in particular, becomes the matter of a necessary secretion, contrived for the strengthening of the organs, and the consolidation of the first elements of the animal. It has been found, that the living bone may be coloured, Colouring
of bones. by taking into the system a colouring substance. This is verified with respect to madder, which colours the bones red. The oldest author that mentions this, according to Beckmann, is Lemnius, in a treatise, *de Miraculis Occultis Naturæ*, in 1564. He was a physician in Zealand, where madder has been cultivated from the earliest ages, and where he had an opportunity of remarking it. He says, the bones of animals become red by eating it's leaves. Mizaldus, who published a book at Paris; in 1566, has taken what he says of it from Lemnius.

In 1736, John Belchier, an English surgeon, (Phil. Trans. vol. 39, p. 287.) may be said to have discovered that madder, on being taken into the system along with food, colours the bones of a red colour. What led to the discovery, was the following. Having dined with a cotton printer, he observed that the bones of the pork, which were brought to the table, were red. On expressing his surprise at this circumstance, his host assured him that the redness was occasioned by the swine feeding on the water mixed with bran, in which the cotton cloth

had been boiled, and which was coloured by the madder used in printing it. Belchier, to whom this effect was new, convinced himself by experiment, that what had been told him was true; that the red colour of the bones arose from the madder, and he communicated his discovery to the Royal Society. This singularity was soon made known, and other experiments were tried. It was found, that besides the roots of madder, those of the galium, (yellow ladies bed straw) and other plants, which have an affinity to madder, produce the same effects.

It appears, that the colouring takes place soonest in young animals, and is strongest where the bones are hardest and thickest. On the other hand, it does not reach the soft parts, and in general is not perceptible in the animal juices, except a little in the milk. Saffron or woad, with many other plants used in dying, have no effect in colouring these hard parts.

HORN.

Horn.

THE horny parts of animals are produced from the forehead, and the extremities; hence they comprise not only the horns, commonly so called, but the hoofs, nails, talons, and claws; which last might, perhaps, afford the best generic characters of horn. These are more or less dry and hard, in some degree flexible, very considerably so when heated, and so cohesive as not to be capable of being pulverized in a mortar; they may likewise be made to receive impressions of different figures, which properties, altogether, are sufficient to distinguish them from bone. Some, however, approach nearer to the last; such are the horns of the stag kind; and seem to form intermediate substances in point of hardness between bone and horn.

Neumann, who distilled a great variety of these substances, found they afforded more or less of the same products as other animal matters; he subjected to this process the horns of the rhinoceros, ox, whalebone, hoof of the elk, &c. from which he obtained an urinous spirit, an empyreumatic oil, volatile salt, and the residue on calcination afforded a fixed saline matter.

Geoffroy obtained, on boiling one pound of hartshorn in water, four ounces, two drachms, and sixty-three grains of dry gelatin; and on distilling one ounce of this, he got two drachms of volatile alkali in a crystallized state; and three drachms, thirty grains of yellow volatile alkaline spirit, with a little dark-coloured empyreumatic oil; there remained two drachms and a half behind.

Dehne obtained from eleven pounds of hartshorn, three pounds of spirit and some oil, and the residue weighed six pounds; and Model and Gunther found in the volatile spirit an ammoniacal salt in cubic or rhomboidal crystals, the acid of which, Leonhardi supposes, was the oxalic or the benzoic.

Macquer informs us, that horn is of the same nature as the gelatinous part of animals, except that it contains less water and a larger proportion of earth; but that, like bone, it may in Papin's digester be totally converted into a gelatinous mass; that it affords by distillation the common products of animal substances, with a pretty large quantity of coal very difficult to incinerate; its ashes contain scarcely any fixed alkali. The animal oil, especially the first that comes over, on being again distilled, is the *oleum animale Dippelii*. Of this the largest proportion is to be got from the horns of the hart and chamois. According to this chemist, these two species contain a larger proportion of the earth of bones, which distinguishes them from the horny substances, and forms a medium between them and bones.

Scheele and
Rouelle.

Scheele and Rouelle obtained the phosphoric acid from calcined hartshorn, and they looked upon it as containing more of this acid than even bones; and Nicholas prefers this substance to the coal, in the preparation of this acid. Although the coal of hartshorn is difficult to incinerate, it undergoes that process much easier than other horns, and nearly equal to bones, and when the coal is exposed to a strong continued heat, it is converted into very white ashes, used in medicine by the name of *cornu cervi ustum*.

Hatchett.

According to Hatchett, if horns are examined, he thinks very few will be found to contain phosphat of lime in such proportion as to be considered an essential ingredient. He does not mean stag or buck horns, for these have every chemical character of bone with some excess of cartilage; but he alludes to those in which the substance of the horn is distinctly separate from the bone, and which, like a sheath, covers a bony protuberance, which issues from the os frontis of certain animals. Horns of this nature, such as those of the ox, the ram, the goat, and the chamois, afford after distillation and incineration, so very small a residuum, of which only a small part is phosphat of lime, that he thinks this latter can scarcely be regarded as a necessary ingredient.

From some experiments made on 500 grains of the horn of the ox, he obtained after a long continued heat only 1,50 grains of residuum; and of this, less than half proved to be phosphat of lime. Seventy-eight grains of the horn of the chamois afforded only 0,50 of residuum, of which less than half was phosphat of lime; and he thinks that so very small a quantity cannot influence the nature of the substances that afforded it. The same may be said of cartilage, which does not contain the ossifying substance, or phosphat of lime, as a constituent principle, but it is mixed as an extraneous matter; and when ab-

sent, both cartilage and horn are most perfect and complete. He thinks the frequent presence of phosphat of lime in cartilaginous substances is not a proof of it's being one of their constituent principles; but only that it has become deposited and mixed with them, in proportion to the tendency they may have to form modifications of bone, or according to their viscosity with such membranes or cartilages, as are liable to such a change.

Hatchett has made some experiments upon the scales ^{Scales.} of different animals: Lewenhoeck had examined the *scales of fish* by means of a microscope; and, as they appear to be formed of different membranaceous laminae, and exhibit the colour and lustre of mother of pearl, it might, as Hatchett observes, be expected, that they should prove to be of a similar nature with the substance of stratified shells, or, in other terms, that they should consist of membrane and carbonat of lime: but; when scales, perfectly clean, and separated from the skin of different fish, such as the salmon and carp, had been immersed during four or five hours in diluted nitric acid, till they became transparent and perfectly membranaceous, the acid liquor being then saturated with pure ammonia, afforded a copious precipitate, which was proved to be phosphat of lime. The *spiculæ* of the shark's skin were found to be of a similar composition, from which he infers, that the spiculæ and scales of fish may be considered as true bony substances, in which the membranaceous parts are more predominant than in common bone.

He found, that phosphat of lime was afforded by the substances only; for when the different skins, from which the scales and spiculæ had been taken, were separately examined, no phosphat of lime was obtained. The silver or pearly hue of fish scales is only assisted and modified by the relative degrees of opacity, produced by the interposition of the phosphat of lime, as the hue in pearl

and mother-of-pearl is by carbonat of lime: for this peculiar lustre principally resides in the membranaceous part, and remains with it, when the acetous or muriatic acid is employed as a menstruum, but is completely destroyed by the nitrous acid. The *horny scales* of serpents, lizards, and such like animals, differ from the foregoing, as they consist merely of the membranaceous or horny substance, in a more or less indurated state, and appear to be devoid of phosphat of lime, as an ossifying matter. Horny scales in general, and the scales of the manis pentadactyla may be mentioned as an example. They afford but very slight traces of gelatin after being boiled in distilled water, and this small portion of gelatin can only be discovered by the tanning principle and by nitro-muriat of tin, unless a very large quantity of the scales has been employed. The hornlike crust, which covers certain insects and other animals, were examined with respect to the gelatin they contained, particularly the plates which covered the body of a large African scorpion, which were not apparently affected, although digested for a long time in boiling distilled water. The tanning principle produced no alteration, when added to the water; but a faint white cloud appeared, upon the addition of nitro-muriat of tin.

SHELLS.

THESE appear to be of a much less compact texture shells. than the bony and horny parts, and want not only the hardness of one but the flexibility of the other ; they are much more brittle, and are easily reduced to a powder. They may be divided into the shells of eggs and the shells of animals.

 EGG SHELLS.

ALTHOUGH all eggs, which are produced by birds, of eggs, are provided with a shell, it has been observed, that very fat hens will sometimes lay them deprived of this hard covering ; but the reason of this exception is unknown. The shell is composed of gelatin, phosphat, and carbonate of lime ; it has, however, been supposed, that the phosphoric acid arises from the gelatinous matter, and is not united with the earth, as in bones ; the truth of which future experience is to determine. Wafferberg observed that, on using the vitriolic acid as a menstruum, there arose a smell of sulphur. Vide Fæces.

 SHELLS OF ANIMALS.

These, like the shells of different eggs, are of various of animals. colours, but far exceed them in beauty as well as in utility. Till lately, however, very little was known with respect to their component parts.

Neumann. According to Neumann, they yield less oily and saline matter by distillation than either horn or bone; he has also observed, that some are more easily converted into quicklime by fire than others, whilst a few suffer no such change.

Hatchett's experiments. For the best analysis of shells we are indebted to Hatchett, whose experiments were made on those of marine animals; and the menstrua, precipitants, and mode of operation he made use of, were the following.

Their division into two kinds. The shells he examined he divides into two kinds, from the substance of which they are composed. The first have a porcellaneous aspect, with an enamelled surface, and, when broken, are often in a slight degree of a fibrous texture. These porcellaneous shells are the various species of *voluta*, *cypræa*, and others of a similar nature. The second kind have, generally, if not always, a strong epidermis, under which is the shell, principally or entirely composed of the substance called *nacre*, or mother-of-pearl, such as the oyster, the river muscle, the *haliotis iris*, and the *turbo olearius*.

These were immersed in acetous acid, or nitric acid diluted, according to circumstances, with 4, 5, 6, or more parts of distilled water; and the solution was always made without heat.

The carbonat of lime was precipitated by carbonat of ammonia, or of potash; and phosphat of lime (if present) was previously precipitated by pure or caustic ammonia.

If any other phosphat, like that of soda, was suspected, it was discovered by solution of acetite of lead.

Tortoise-shell. 500 grains of tortoise-shell yielded 80 grains of coal; from which 3 grains of earthy matter being deducted, 77 grains remain for the proportion of coal. These three grains consisted of phosphat of soda and lime, with some traces of iron; but Hatchett thinks it probable that the

latter was accidentally present. Tortoise-shell appears to be formed (as far as organic arrangement is concerned) in the way of stratum super stratum, and this structure is particularly to be discovered after long maceration in diluted nitric acid; for then this shell appears to be composed like the black polished gorgonia, of membranaceous laminæ, and the varieties of horn differ only by a tendency to the fibrous organization.

PORCELLANEOUS SHELLS.

SHELLS of this description, when exposed to a red heat in a crucible for about a quarter of an hour, crackled and lost the colours of their enamelled surface; they did not emit any apparent smoke, nor any smell, like that of burned horn or cartilage. Their figure remained unchanged, excepting a few flaws, and they became of an opaque white, tinged partially with pale gray, but retained part of their original gloss. Porcel-
laneous
shells.

Fresh shells (whether entire or in powder) dissolved with great effervescence in the various acids, and the solution afterwards remained colourless and transparent; but the burned shells, on being dissolved, deposited a very small quantity of animal coal; and thereby the presence of some gluten was denoted, although the proportion was too small to be discovered in the solution of the fresh unburned shells.

The various solutions were filtered and examined by pure ammonia and acetite of lead; but there was no trace of phosphat of lime, nor of any other combination of phosphoric acid.

The carbonat of lime was afterwards precipitated by carbonat of ammonia; and from many experiments it

appeared, that porcellaneous shells consist of carbonat of lime, cemented by a very small portion of animal gluten.

Patellæ.

Previous to the experiments on the second sort of shells, this chemist examined some patellæ from Madeira. Exposed to a red heat in a crucible, there was a perceptible smell, like that of horn, hair, or feathers. The proportion of carbonic matter, deposited by the subsequent solution, was more considerable than that of the porcellaneous shells, and the proportion of carbonat of lime, relative to their weight, was less.

When the recent shells were immersed in very dilute nitric acid, the epidermis was separated, the whole of the carbonat of lime was dissolved, and a gelatinous substance, nearly liquid, remained; but without retaining the figure of the shell, and without any fibrous appearance.

These shells, therefore, contain a larger proportion of a more viscid gelatinous substance than the porcellaneous, but the solution separated from this gelatinous substance afforded nothing but carbonat of lime.

Pearly
shells.
Oyster
shell.

Pearly shells. In the examination of the shells composed of nacre or mother-of-pearl, he found that, on exposing the shell of the common oyster to a red heat, the effects were the same as those observed in the patellæ, and the solution of the unburned shell was similar, only the gelatinous part was rather of a greater consistency.

Muscles.

A species of river muscle was next subjected to experiment. This, when burned in a crucible, emitted much smoke, with a strong smell of burned cartilage or horn; the shell throughout became of a dark gray and exfoliated. By solution in the acids, a large quantity of carbonic matter was separated, and much less carbonat of lime was obtained from a given weight of the shell, than from those already mentioned.

On immersing an unburned shell in dilute nitric acid, a rapid solution and effervescence at first took place, but gradually became less; so that the disengagement of the carbonic acid gas was to be perceived only at intervals. At the end of two days, nearly the whole of the carbonat of lime was dissolved, but a series of membranes retaining the figure of the shell remained; of which the epidermis constituted the first. In the beginning, the carbonat of lime was readily dissolved, because the acid menstruum had an easy access; but after this, it had more difficulty to insinuate itself between the different membranes, and of course the solution of the carbonat of lime was slower. During the solution, the carbonic acid gas was entangled, and retained in many places between the membranes, so as to give the whole a cellular appearance.

The *haliotis iris*, and the *turbo olearius*, resembled this muscle, excepting that their membranaceous parts were more compact and dense. These shells, when deprived of their hardening substance, or carbonat of lime, by an acid menstruum, appear to be formed of various membranes, applied stratum upon stratum. Each membrane has a corresponding coat, or crust of carbonat of lime; which is so situated, that it is always between every two membranes, beginning with the epidermis, and ending with the last formed internal membrane.

The animals which inhabit these stratified shells increase their habitation by the addition of a stratum of carbonat of lime, secured by a new membrane; and as every additional stratum exceeds in extent that which was previously formed, the shell becomes stronger in proportion as it is enlarged; and the growth and age of the animal becomes denoted, by the number of the strata which concur to form the shell.

Although the *haliotis iris*, and the *turbo olearius*, are

composed of the true mother of pearl, this chemist was induced to repeat the foregoing experiments, on some detached pieces of mother of pearl, such as are brought from China, and the results were precisely the same.

Mother of
pearl.

He, however, observes, that the membranaceous, or cartilaginous parts of these shells, as well as of the pieces of mother of pearl, retained the exact figure of the shell or piece, which had been immersed in the acid menstruum; and these membranaceous parts distinctly appeared to be composed of fibres, placed in a parallel direction, corresponding to the configuration of the shell.

Pearls.

The same experiments were made on pearls, which proved to be similar in composition to the mother of pearl; and so far as the size would enable him to discern, they appeared to be formed by concentric coats of membrane, and carbonat of lime; by this structure, they much resemble the globular calcareous concretions, formed at Carlsbad, and other places, called pisolithes.

The wavy appearance, and iridescency of mother of pearl, and of pearl, are evidently the effects of their lamellated structure, and semitransparency, in which, in some degree, they are resembled by the lamellated stone, called adularia.

Porcellane-
ous and
pearly shells
compared.

When the experiments on the porcellaneous shells, and on those formed of mother of pearl, are compared, it appears, that the porcellaneous shells are composed of carbonat of lime, cemented by a very small portion of gluten; and that mother of pearl, and pearl, do not differ from these, except by a smaller proportion of carbonat of lime; which, instead of being simply cemented by animal gluten, is intermixed with, and serves to harden a membranaceous or cartilaginous substance; and this substance, even when deprived of the carbonat of lime, still retains the figure of the shell.

But between these extremes, there will probably be found many gradations, and these we have the greater

reason to expect, from the example afforded by the patellæ.

Hatchett having stated the difference between porcellaneous shell and mother of pearl, thinks it is not possible to avoid the comparing of these to enamel and tooth.

Porcellaneous shell compared with enamel and tooth.

When porcellaneous shell, whole or in powder, is exposed to the action of acids, it is completely dissolved, without leaving any residuum; and enamel is also completely dissolved in the like manner.

Porcellaneous shell and enamel, when burned, emit little or no smoke, nor scarcely any smell of burned horn or cartilage. Their figure, after exposure to fire, is not materially changed, except by cracking in some parts; their external gloss partly remains, and their colour at most becomes gray, very different from what happens to mother of pearl, or tooth. In their fracture, they have a fibrous texture; and in short, the only essential difference between them appears to be, that porcellaneous shells consist only of carbonat of lime, and enamel of phosphat of lime, each being cemented by a small portion of gluten.

In like manner, if the effects produced by fire and acid menstrua, on shells composed of mother of pearl, and on the substance of teeth and bone, are compared, a great similarity will be found; for when exposed to a red heat,

Mother of pearl with bone and tooth.

1st. They smoke much, and emit a smell of burned cartilage, or horn.

2d. They become of a dark gray or black colour.

3d. The animal coal thus formed is of difficult incineration.

4th. They retain much of their original figure; but the membranaceous shells are subject to exfoliate.

5th. These substances (pearl, mother of pearl, tooth, and bone) when immersed in certain acids, part with their hardening or ossifying substances, and then remain in the state of membrane or cartilage.

6th. When previously burned, and afterward dissolved in acids, a quantity of animal coal is separated, according to the proportion of the gelatinous, membranaceous, or cartilaginous substance, and according to the duration of the red heat.

And lastly, the acid solutions of these substances, by proper precipitants, afford carbonat of lime in the one case, and phosphat principally in the other, in a proportion relative to the membrane or cartilage, with which, or on which, the one or the other had been mixed, or deposited.

As porcellaneous shell principally differs from mother of pearl, only by a relative proportion between the carbonat of lime, and the gluten, or membrane, in like manner, the enamel appears only to be different from tooth or bone, by being destitute of cartilage, and by being principally formed of phosphat of lime, cemented by gluten.

The difference in the latter case seems to explain why the bones and teeth of animals fed on madder became red; when at the same time, the like colour is not communicated to the enamel; for it appears probable, that the cartilages which form the original structure of the teeth and bones, become the channels by which the tingeing principle is communicated and diffused. These comparative experiments prove, that there is a great approximation in the nature of porcellaneous shell and the enamel of teeth, and also in that of mother of pearl and bone; and if a shell should be found composed of mother of pearl, coated by the porcellaneous substance, it will resemble a tooth coated by the enamel, with the

difference of carbonat being substituted for the phosphat of lime.

Some few experiments were made on certain land shells; Snail shells. and in that of the common garden snail this chemist thought he discovered some traces of phosphat of lime, but as he found none in the *helix nemoralis*, it may be doubted whether the presence of the phosphat of lime should be considered as a chemical character of land shells.

Experiments on the substance, called the bone of the Bone of the cuttle fish. cuttle fish, proves, that it is exactly similar to shell in composition, and consists of various membranes, hardened by carbonat of lime, without the smallest mixture of phosphat; and of course is improperly called a bone.

CRUSTACEOUS PARTS.

Crustaceous parts.

HATCHETT not being acquainted with any experiments, by which the chemical nature of the substance which covers the different crustaceous marine animals, as the echini, star fish, crabs, lobsters, &c. had been determined, was desirous to ascertain in what respect it differed from shell; and he began his experiments on three species of echinus. He was the more inclined to begin with the echini, because naturalists do not appear to be perfectly agreed, whether to call them testaceous or crustaceous animals; for Klein, who has written a book upon them, regards them as belonging to the first tribe; whilst Linnæus, on the contrary, looked upon them as of the second. Now, as the experiments above related had proved that the shells of marine animals were composed of carbonat of lime, without any phosphat, this chemist thought it very possible, that

the covering of the crustaceous animals might, in some respect, be different; and if so, he might be enabled, by chemical characters, to ascertain the class to which the echinus was to be referred.

Echini.

Of the three echini examined, one had small spines; the second had large obtuse spines, and the third was of a very flat form.

Portions of these echini were separately immersed in acetous, muriatic, and diluted nitric acid, by each of which they were completely dissolved, with much effervescence, depositing at the same time a thin outer skin or epidermis. The transparency of the solutions was also disturbed by a portion of gluten, which remained suspended, and communicated a brownish colour to the liquors.

The solutions in acetous and diluted nitric acids were filtered; after which, from the acetous solution of each echinus, a precipitate of phosphat of lead was obtained, by the addition of acetite of lead; and having thus proved the presence of phosphoric acid, the nitric solutions were saturated with pure ammonia, by which a quantity of phosphat of lime was obtained, much inferior, however, in quantity to the carbonat of lime, which was afterward precipitated by carbonat of ammonia.

The composition of the crust of the echinus is therefore different from that of marine shells, and by the relative proportions and nature of the ingredients, it approaches most nearly to the shells of the eggs of birds; which, in like manner, consist of carbonat, with a small proportion of phosphat of lime, cemented by gluten.

Asterias.

It remained now to examine the composition of those substances, which are decidedly called crustaceous; but previous to this, some experiments were made on the asterias, or star fish, and that species was used which is commonly found on our coasts, known by the com-

mon name of five fingers, or the *asterias rubens* of Linnæus.

When the *asterias* was immersed in the acids, a considerable effervescence was produced, and a thin external stratum was dissolved; after which, it remained in a perfectly coriaceous state, and complete, in respect to the original figure. The dissolved portion, being examined by the usual precipitants, proved to be carbonat of lime, without any mixture of phosphat; but in another species of the *asterias*, with twelve rays, or the *asterias papposa* of Lin. a small quantity of phosphat of lime was discovered. This chemist was therefore induced to suspect, that in the different species of *asterias*, nature makes an imperfect attempt to form shell on some, and a crustaceous coating on others; and that a series of gradations is thus formed between the testaceous, the crustaceous, and the coriaceous marine animals.

It was now requisite to ascertain, whether phosphat of lime were a component part of the substance which covers the crustaceous, marine, or aquatic animals; such as the crab, lobster, prawn, and crayfish. Crab, lobster, prawn, and crayfish.

Pieces of this substance, taken from various parts of those animals, were at different times immersed in acetic, and in diluted nitric acid; those which had been placed in the diluted nitric acid produced a moderate effervescence, and in a short time were found to be soft and elastic, of a yellowish white colour, and like a cartilage which retained the original figure. The same effects were produced by acetic acid, but in a less degree; in the latter case also, the colouring matter remained, and was soluble in alcohol.

All the solutions, both acetic and nitric, afforded carbonat and phosphat of lime, although the former was in the largest proportion.

Crustace-
ous, com-
pared with
testaceous
substances.

There is reason to affirm, therefore, that phosphat of lime, mingled with the carbonat, is a chemical characteristic, which distinguishes the crustaceous from the testaceous substances, and that the principal difference in the qualities of each, when complete, is caused by the proportion of the hardening substance, relative to the gluten, by which they are cemented; or by the abundance and consistency of the gelatinous, membranous, or cartilaginous substance, in and on which, the carbonat or the mixture of carbonat and phosphat of lime, has been secreted and deposited. Moreover, as the presence of phosphat of lime, mingled with carbonat, appears to be a chemical character of crustaceous marine animals; there is every reason to conclude, that Linnæus did right not to place the echini among the testaceous ones.

The presence of phosphat of lime, in the substance which covers the crustaceous marine animals, appears to denote an approximation to the nature of bone; which not only by the experiments of Galin, but by the united testimony of all chemists, has been proved principally to consist (as far as the ossifying substance is concerned) of phosphat of lime.

Conclusion. By the experiments on various shells, crustaceous substances, and bones, it is therefore proved according to Hatchett,

1. That the porcellaneous shells resemble the enamel of teeth in the mode of formation, but that the hardening substance is carbonat of lime.

2. That shells composed of nacre, or mother of pearl, or approaching to the nature of that substance, and also pearls, resemble bone in a considerable degree, as they consist of a gelatinous, cartilaginous, or membranaceous substance, forming a series of gradations, from a tender and scarcely perceptible jelly, to membranes completely organized, in and upon which, carbonat of lime is

secreted and deposited after the manner that phosphat of lime is in the bones ; and therefore as the porcellaneous shells resemble the enamel of teeth, so the shells formed of mother of pearl, &c. in like manner, resemble bone ; the distinguishing chemical character of the shells being carbonat of lime, and that of enamel and bones being phosphat of lime.

3. That the crust which covers certain marine animals, such as crabs, lobsters, crayfish, and prawns, consists of a strong cartilage, hardened by a mixture of carbonat and phosphat of lime ; and that thus these crustaceous bodies occupy a middle place between shell and bone, although they incline principally to the nature of shell.

4. And lastly, that a certain proportion of carbonat of lime enters the composition of bones in general ; the proportion of it, however, being to the phosphat of lime, *vice versa*, to that observed in the crustaceous marine substances. Upon the view, therefore, of these facts, it is evident, that there is a great similarity in the construction of shell and bone, and that there is even an approximation in the nature of their composition, by the intermediate crustaceous substances.

Zoophytes.

ZOOPHYTES.

Examined
by Bouvier
and Du-
rande.

THE component parts of the zoophytes were but little known before the experiments of Hatchett. Bouvier had, however, made an analysis of the *corollina officinalis*; and Durande had somewhat investigated *corollina subpinata*. The first found, that 1000 grains of the *c. offic.* were composed of,

| | |
|--------------------------------|-------|
| 1. Muriat of soda | 10 |
| 2. Gelatin | 66 |
| 3. Albumen | 64 |
| 4. Sulphat of lime | 19 |
| 5. Silex | 7 |
| 6. Iron | 2 |
| 7. Phosphat of lime | 3 |
| 8. Magnesia | 23 |
| 9. Lime | 420 |
| 10. Carbonat of lime | 196 |
| 11. ————— magnesia .. | 51 |
| 12. Water | 141 |
| | <hr/> |
| | 1002 |

The latter procured, on distillation of the *c. subpin.*, volatile alc. with phlegm, and an oil, and found the earth to be calcareous; he looks upon it as a plant impregnated with a large quantity of calcareous earth and animal matter.

Preliminary
observati-
ons by Hat-
chett.

Hatchett, in his experiments upon the different genera of zoophytes, adopted a similar mode to that which he employed in his experiments, before mentioned in this article. He observes, however, that as argill is not un-

frequently lodged, as an extraneous substance in the interstices of many of the madrepores, and such like bodies ; and as argill is precipitated by pure ammonia, it was necessary, not to rely merely on the ammonia, as a test of phosphat of lime. Wherever, therefore, any precipitate was produced by ammonia, it was dissolved again in acetous acid, and this solution was examined by the addition of acetite of lead.

It appears that the minutiae of analysis in the experiment did not form part of his plan, which was only to sketch an outline, comprehending the most prominent chemical characteristics of certain bodies belonging to the animal kingdom, which hitherto had been but little or not at all examined ; so that this outline, although defective, might serve as a chain of connection, and as a basis, upon which a more perfect superstructure may in future be gradually raised ; and it appeared to him, that this would be most speedily and easily executed by following a systematic and comparative plan. For this reason a great part of his attention was directed towards ascertaining, in these animal substances, the presence and general proportions of carbonat and phosphat of lime ; these being the materials essentially employed by nature to communicate rigidity and hardness to certain parts of animals, such as shell and bone ; and although some other substances, as magnesia, flex, iron, and some alkaline and neutral salts, might be occasionally present in small proportions, (and indeed were at times detected) yet, as they appear to have but little influence on the general characters of the bodies which were examined, he did not think proper to take particular notice of them. The next object was, to examine the nature of the substance in and upon which the hardening or ossifying principles were secreted and deposited ; -and it appeared to him the best mode of performing it was to compare and examine this substance in the

various states in which it appeared, when deprived of the hardening or ossifying matter.

From what Hatchett has said on shell and bone, concerning the substance which remained after the carbonat of lime in shells, and after the phosphat of lime in bones, had been dissolved and separated by weak acids, it is evident, that the substance which thus remains is as various in relative quantity, as it is in those qualities which apparently are produced by the degrees of natural inspissation, and by the progressive effect of organization. In the porcellaneous shells, such as *cypræa*, &c. this substance he proved to be much less in quantity than in those which were afterwards mentioned, and although of a quality which, (like a cement or gluten) seemed to bind and connect the particles of carbonat of lime firmly together, so small was the degree of natural inspissation, and so little advanced was the degree of organization, that, when the carbonat of lime was dissolved, even by very feeble acids, little or no vestige of jelly, membrane, or cartilage, could be perceived; nor indeed could any be detected, but by the small portion of animal coal which was formed, when these shells had been exposed for a short time to a low red heat.

But proceeding from shells of this description to others tending to the nature of nacre or mother-of-pearl, (such as some of the *patellæ*) a substance was left *untouched by the acids*, which had the appearance of a yellowish transparent jelly; so that the substance, which served merely as a gluten in the porcellaneous shells, was not only more abundant in the *patellæ*, but, being more inspissated, was become immediately visible and palpable.

In the common oyster, the qualities were more strongly marked; and in the river muscle, and in the shells composed of the true nacre or mother-of-pearl, this substance was found not only to constitute a large part of the shell,

but even to be more dense, so as no longer to appear gelatinous ; and, in addition to these, strong and visible marks of organization were stamped on every part, and a perfect membranaceous part remained, composed of fibres arranged parallel to each other, according to the configuration of the shells.

From the facts proved by the examination of only a very few (comparatively speaking) of the known shells, it appears, that the hardening principle or carbonat of lime, together with a substance varying from a very attenuated gluten to a tough jelly, and from this to a perfectly organized membrane, concur to form the matter of shell ; and from the result of the experiments, and from all circumstances, there is every reason to believe, that the substance with which, or upon which, the carbonat of lime is mixed or deposited, is of a similar nature, and differs only in relative quantity or density, arising from progressive changes (peculiar to the various species of shells) produced by certain degrees of natural inspissation, and by an organization more or less perfect.

The experiments made on teeth and on the bones of various animals, elucidated and confirmed the observations made on the nature of shell ; for,

1. The enamel of teeth (in relation to the other bony substances) was proved to be, as the porcellaneous shells are to those formed of mother-of-pearl ; the cementing substance of enamel being a gluten, in the same state and apparently of a similar nature with that of the porcellaneous shells. And,

2. In certain bones, particularly those of fish, (such as some of the bones of the skate) the substance, which remained after the solution of the phosphat of lime, was of a gelatinous consistency, and exhibited but very imperfect traces of organization ; by the others, however, a com-

pletely formed membrane, or cartilage, was left, retaining the figure of the original bone.

When, therefore, the component parts of shell and bone are considered, it appears, that the essential characteristics are, carbonat of lime for the one, and phosphat of lime for the other; and that their bases consist of the modifications of a glutinous, gelatinous, or membranaceous substance. The term jelly Hatchett only employs to denote the degree of consistency of this substance, which, in it's nature, is very different from the varieties of animal jelly called gelatin.

Having traced the progressive and connected changes in the composition of the various shells and bones, Hatchett found his observations on those bodies corroborated, and the chain of connection extended, by the development of the facts resulting from his experiments on zoophytes; and, having made the preliminary observations, it will be now proper to take a view of these experiments, and to examine how far they tend to prove, that the substances are all of a nature closely connected.

His experiments on madrepores.

The *madrepora virginia*, when immersed in very dilute nitric acid, effervesced much, and was soon dissolved. The solution was perfectly transparent and colourless, with but a small appearance of gelatinous or membranaceous particles. Pure ammonia was then added, but produced no change, and the whole of what had been dissolved, was afterwards completely precipitated by carbonat of ammonia, and proved to be carbonat of lime. The *muricata* and the *labyrinthica* afforded loose portions of a transparent gelatinous substance. *M. ramea* and *m. fascicularis*, when deprived of the carbonat of lime by acids, remained in the state of completely organized and membranaceous bodies, which exhibited the original figure of

the respective madrepores ; and the proportion of coal, afforded by them, was more abundant than what was obtained from the first mentioned.

Millepora cerulea. This produced much effervescence Millepores. in very dilute nitric acid. The blue colour disappeared as the calcareous part was dissolved, and was not afterwards restored by ammonia. It afforded loose detached portions of a gelatinous substance.

M. alcornis yielded the same, but in a more coherent state ; but it did not retain the figure of the millepore. *M. polymorpha* remained unchanged in shape, and consisted of a strong, white, opaque membrane, filled with a transparent jelly. Ammonia produced a very slight precipitate from the solution in nitric acid, which, being dissolved in acetous acid, was proved to be phosphat of lime, by solution of acetite of lead. Carbonat of soda afterward precipitated a large quantity of carbonat of lime. Lastly, *m. cellulosa*, *m. fascialis*, and *m. truncata* afforded membranaceous bodies in a complete state of organization, and all the *madrepores* and *millepores*, when exposed to a low red heat in a crucible, emitted smoke, with the smell of burned horn or feathers, became tinged of a pale or deep gray colour, and, when dissolved in acids, deposited more or less animal coal, in proportion to the quantity of the gelatinous or membranaceous substance detected by the above experiment.

The universal and only hardening principle of these *madrepores* and *millepores* was proved to be carbonat of lime, with the single exception of *millepora polymorpha*, which also appears to be differently constructed from the other *milleporæ* ; with this single exception, carbonat of lime seems to be the only hardening substance in these bodies, and, when every circumstance is considered, an exact similarity is to be found between the substance forming the various shells, and that which forms the *madrepores* and

millepora; and the nature of these bodies is so completely the same, that the changes or gradations of the one are to be found in the other. For the chemical characters which distinguish the porcellaneous shells are in a great measure approached by those of *madrepora virginia*, and those which are noticed in the *pateila* correspond precisely with the madrepores and millepores, which afford a gelatinous substance; and, lastly, the characters of the membranaceous part, exhibited by the shells formed of nacre or mother-of-pearl, are in like manner to be found among some of the madrepores and millepores; such as *madrepora ramea*, *millepora fascialis*, *m. truncata*; for these, like the *turbo clearius* and *halotis iris*, are composed of a fibrous membrane, hardened by carbonat of lime.

It appears therefore, that the madrepores and millepores, like the various shells, are formed of a gelatinous or membranaceous substance, hardened by carbonat of lime, and the only difference is in the mode according to which the materials have been employed.

Tubiporæ. Of the tubiporæ he had only an opportunity of examining the *tubipora musica*. Like the former substances, it was immersed in an acid, and, on this occasion, he employed the acetous acid. A great effervescence was produced, and the red colour was destroyed; in proportion as the calcareous part was dissolved, some loose particles of a tender membrane floated in the liquor. Pure ammonia produced a precipitate of argill, accidentally lodged in the interstices of the tubipore. From the filtrated liquor, carbonat of potash precipitated a large quantity of carbonat of lime.

Flustra. When the *flustra foliacea* was immersed in very dilute nitrous acid, an effervescence of short duration took place, and when this had ceased, the *flustra* appeared like a finely reticulated membrane, which retained the original shape. Pure ammonia, added to the filtrated solution, produced

a slight precipitate, which, dissolved in acetous acid, was found by acetite of lead to be phosphat of lime. On adding afterwards a solution of carbonat of ammonia, a copious precipitate of carbonat of lime was produced. When the *flustra foliacea* was exposed to a low red heat in a crucible, it emitted a smell like burned horn; but retained its shape, by reason of the carbonat of lime, with which it was coated. The *flustra*; thus burned and dissolved in dilute nitric acid, deposited some animal coal; but in other respects, the present solution resembled the former nitric solution of this substance, when in a recent state. When the *flustra foliacea* was long digested with boiling distilled water, it communicated to it a pale brownish tinge. Infusion of oak bark, being poured into the liquor, did not produce any visible effect, even after 24 hours had elapsed; but nitro-muriat of tin formed a white cloud in a few minutes.

Coralline, like the *flustra foliacea*, produced in very dilute Corallina. nitric acid an effervescence of short duration. The coralline then remained in a membranaceous state, and retained the original figure. Pure ammonia produced scarcely any effect. Carbonat of ammonia precipitated a large quantity of carbonat of lime. Some of the coralline was then exposed in a crucible to a low red heat, when it emitted a smell of burned horn, and retained in great measure its shape, evidently from the calcareous coating. The burned coralline, dissolved in dilute nitric acid, deposited some animal coal. The clear solution afforded by pure ammonia a very slight precipitate of phosphat of lime, after which the carbonat of lime was precipitated as before.

The experiments, therefore, on the *tubipora musica* prove its resemblance, in composition, to the substances before it; but a slight difference was observed in the hardening substance of the *flustra foliacea* and *corallina opuntia*; for

a small portion of phosphat was found mixed with the carbonat of lime, as first observed; but the membranaceous part of these bodies resembles that of certain madrepores and millepores, particularly *millepora fascialis*.

Iris.

When the *iris ochracea* was immersed in dilute nitric acid, a considerable effervescence was produced, and, in proportion as the calcareous substance was dissolved, the red colouring matter was deposited in the state of a fine red powder. This colouring substance was neither dissolved nor changed, when nitric or muriatic acid was poured upon it. It appears therefore to be very different from the tingeing matter of the *tubipora musica*, or that of the *gorgonia nobilis*. When the effervescence had ceased, (in about three hours) a yellowish membrane remained, which completely retained the original figure of the iris. A slight precipitate of phosphat of lime was separated from the filtrated solution, when saturated with pure ammonia. A large quantity of carbonat of lime was afterward precipitated by carbonat of potash.

Part of a branch of this iris was exposed to a low red heat; it smoked and smelled like burned horn, and, in a few minutes, the branch separated at the knotty joints into as many pieces as there were joints in the branch. These joints had all the character of coal; but the whole of the membrane, which had invested them, as well as the knotted protuberance, by which they had been connected, were destroyed, by being converted into coal. From this Hatchett was desirous to examine the internal structure of the membranaceous part, out of which these joints of coral had been dissolved by acids. He therefore took the membranaceous substance, which retained the complete figure of the iris; and this, being opened longitudinally, exhibited a series of cavities, corresponding in form with the coralline joints, and so situated, that each of these cavities extended from one bulb, or knot, nearly

to the next, throughout the whole of the branch. The coralline joints, when viewed separately, appeared smaller in the middle than at the ends, which were terminated by obtuse cones. In the branch these joints were so placed, that the extremities or cones were opposed point to point, but were prevented from immediate contact by a gristly substance, which filled, and, indeed, principally formed in the branch the knot or knob of each joint, and was interposed between the cones of the coralline substance, like the common cartilage of the articulations. From this construction it appears, that this iris is capable of great flexibility when in a recent state; for the gristly part of the bulbs is then, most probably, much softer and more elastic than the dried specimens. The gristly substances, which form the bulbs and the coralline joints, are kept together and covered by a thin membrane or skin, continued over the whole like a tube. The joints are not therefore devoid of coating, as seems implied by the definition of Linnæus. *Iris hippuris* was similar to the above, except possessing carbonat of lime. A tube of membrane, however, invests the curious structure of the before mentioned iris, whilst in this no such tube or outer coat exists; for the coralline joints (like some of the madrepores, millepores, &c.) consist of a membranaceous substance, hardened by carbonat of lime; and the only difference appears to be, that in the madrepores and millepores the membranaceous part is less compact and abundant; but even the striæ of the coralline joints remain visible and unchanged in the membrane of this iris.

The horny part forms also a marked characteristic in this iris, and seems to approach it to certain of the gorgoniæ. This horny part does not, however, pervade the whole of the branch; for where the coralline joints commence, this horny substance immediately terminates,

internally as well externally, and is not to be discovered but between, or in the separation of, these joints.

Hence both of these irises are formed of regularly organized, membranaceous, cartilaginous, and horny substances, hardened in the last mentioned species merely by carbonat of lime, but in the *iris ochracea* with the addition of a very small portion of phosphat of lime.

Gorgonia.

Dr He made experiments on different pieces of the *gorgonia nobilis*, or red coral, some of which were polished and deprived of their external pale red mealy coat, whilst others were in their original state. They both afforded carbonat of lime, and the unpolished red coral, whether in diluted nitric acid, or in acetous acid, had it's calcareous part completely dissolved, and there remained an external tubulated membrane of a pale yellow colour, retaining the original figure, and filled with a transparent gelatinous substance. The polished or uncoated red coral, treated in the same manner, left a transparent gelatinous substance like the other, except that it was not in detached portions. This solution, like the former, only yielded carbonat of lime. In each of these experiments the red colour of the coral was gradually destroyed, as the solution of the calcareous substance advanced, and could not afterwards be restored, nor could any colouring principle whatever be detected by the reagents usually employed. When the coated or uncoated coral was exposed to a slow red heat, which produced a smell of burned horn, it had lost it's red colour, and became gray, and being afterwards dissolved in dilute nitric acid, and the precipitate by ammonia again dissolved in acetous acid, phosphat of lead was obtained on the addition of acetite of lead. The carbonat of lime was afterwards precipitated in the usual manner. Hence this *gorgonia* consists of two parts, one of which is the stem formed of a gelatinous substance, hardened by carbonat of lime, and coloured by some unknown modification of animal matter; the other is a

membranaceous tube, which, like a cuticle or context, coats the stem, and when deprived of it's hardening substance, possesses all the characters of membrane. But although carbonat of lime could only be discovered when this *gorgonia* was simply immersed in acids, yet it appears a small portion of phosphat of lime is also present, but so enveloped by the membranaceous and gelatinous parts, as not to be dissolved by the acid menstrua, till these substances have been decomposed by fire. This is not an unusual circumstance, when a very small portion of a substance is enveloped by large quantities of other matter; for Bergman observes it, with respect to the *calculus vesicæ*, in his supplement to Scheele's essay. Hatchett does not, however, pretend to determine, whether the very small portion of phosphat of lime in this *gorgonia* be an essential ingredient or not, but the mode of construction evidently proves how much this *gorgonia* differs from the madrepores and millepores, as well as from the following *gorgonia*, *G. ceratophyta*. It effervesced in dilute nitric acid, after which solution the cortical part appeared like a thin yellowish membrane, investing the stem, which was become transparent and similar to cartilage. The solution afforded a large quantity of phosphat of lime by ammonia, and lixivium of potash separated some carbonat of lime. The cortex scarcely afforded a vestige of phosphat of lime, but a considerable quantity of carbonat. On the contrary, the stem afforded the phosphat in large quantity and very little of the last. When burned in a crucible, it smelled like burned horn, but the figure was not destroyed; and when afterwards dissolved in the acid, it yielded the same product as before. *G. flabellum*. In dilute nitric acid it's effervescence was short, and the cortical part appeared like a thin yellowish membrane, which covered the stem. The latter was transparent, and resembled softened horn of a reddish brown colour. The solution afforded a large

quantity of phosphat of lime, and a less copious precipitate of carbonat. The solution of the cortex was scarcely rendered turbid by ammonia; but afforded a considerable portion of carbonat of lime by potash. The stem, from which the cortical part was taken, being steeped three days in diluted nitric acid, became soft, elastic, and, in some measure, cartilaginous: it contained a deal of phosphat, but very little carbonat of lime. The recent stem, in great measure, retained it's shape when put into a red hot crucible; but that which had been steeped in the acid curled up, and soon became a shapeless mass of coal, which by a longer heat was completely dissipated. This difference appears to have been caused by the phosphat of lime, present in the recent stem, but dissolved and separated in the latter case by the acid. Hatchett observes likewise, that the different effects are to be observed, when bone and when the cartilage or membrane, which remains after bone has been long steeped in acids, are exposed to a red heat.

These experiments prove, that the *G. flabellum*, like the *G. ceratophyta*, consists of a horny stem, containing a certain proportion of phosphat of lime, and that this stem is invested with a membrane, hardened principally by carbonat of lime, which seems to cover and defend it in the manner of a shell. *G. suberosa*. The cortical part being separated from the stem was first subjected to experiment. In dilute nitric acid, after an effervescence of several hours, a soft yellowish membranaceous substance remained, retaining the original figure. The solution contained a little phosphat of lime, and a large portion of the carbonat. Some of the pieces of the cortex, boiled in distilled water six hours, afforded a great deal of gelatin by means of infusion of oak bark. The same pieces afterward boiled with lixivium of caustic potash were dissolved, and formed the animal soap of Chaptal; the cal-

careous part subsided to the bottom. The cortical part exposed in a red hot crucible, smelled like burned horn, and fell to pieces, which, being dissolved in nitric acid, gave a little phosphat and a great deal of the carbonat of lime. The stem, on being steeped fourteen or fifteen days in the dilute acid, tinged it of a pale yellow. After this, the stem was more transparent and flexible, approaching to cartilage; ammonia changed the yellow liquor to a deep yellow or orange colour; but there was no precipitate, even when carbonat of potash was added. Part of a stem, cut in small pieces and boiled in water, afforded gelatin in small quantity, and caustic potash formed with it Chaptal's animal soap. The stem, in a red heat, curled up and smelled like horn, and by a long continuation of the heat, the scarcely to be collected residuum dissolved in dilute acid, gave by ammonia a slight portion of phosphat of lime. Another species, which most resembled the *suberosa*, except that the cortical part was much longer in proportion to the stem, proved to be of a similar composition with the above. *G. pectinata*. The cortical part gave a little phosphat of lime and a large portion of carbonat. The stem resembled those described. *G. fetosa* effervesced in dilute nitric acid, and after some hours, the cortical part appeared a thin yellowish membrane, which coated the horny stem. The solution contained a slight portion of phosphat and a large one of carbonat of lime. When the cortex was separately steeped in the acid, and the solution examined as before mentioned, only carbonat was obtained. On the contrary, the stem, whether recent or burned, gave a little phosphat, but scarcely any trace of carbonat. The stem became in the acid soft and transparent, like cartilage. Thus the gorgoniæ already enumerated resemble each other much in the composition of their cortices, as well as in the nature of their stems. In the cortex the

predominant hardening substance is carbonat of lime; but, in the stem, phosphat of lime is the chief, and almost the only earthy substance that is présent.

The following *gorgoniae*, although invested also with a cortex, are different, as they do not afford any phosphat of lime. The *g. umbraculum*, *verrucosa*, and three other species not described, nearly resemble each other. Their cortical parts in dilute acid effervesced, and became soft, pulpy, yellowish white membranaceous bodies, with nearly their original form and size. The acid solutions gave no phosphat, but a large proportion of carbonat of lime. The stems, left fourteen days in the acid, were very little affected, except becoming soft and transparent, resembling cartilage or softened horn; and they became of a deep reddish orange colour, inclining to brown, in pure ammonia, and in a few hours were completely dissolved. The acid, in which they were steeped, afforded no precipitate.

The remaining *gorgoniae* differ from the former, as they are not coated with a fleshy or pulpy cortical substance. They are here placed immediately before the *antipathes*, on account of their great similarity in chemical properties as well as in external appearance. *G. antipathes*. Some pieces of this *gorgonia* were immersed in dilute nitric acid during three weeks, in which they became soft, and appeared to be composed of a pale brown, opake, membranaceous substance, which formed concentric coats of a ligneous aspect. The acid was become pale yellow, and ammonia changed it to orange colour; but neither it nor potash produced any precipitate. The *gorgonia* boiled six hours in diluted water tinged it yellow, and, on adding infusion of oak bark, a small portion of gelatin was precipitated. The pieces thus treated formed a dark coloured animal soap with caustic potash. The *gorgonia* exposed to a red heat, swelled like burned horn, soon lost

its shape, puffed up, and formed a spongy coal, which by a long continued heat left a few particles of a white substance, chiefly muriat of soda. *Another species* of gorgonia was then examined, the stem of which is from a quarter to nearly half an inch in diameter in the thickest part, of a black colour, high polish, like black sealing-wax, and has probably been considered a variety of the *G. antipathes*. On immersion 28 days in dilute acid, it gradually became transparent, of a bright brownish yellow. In this soft state it was steeped two days in water, and then opened longitudinally. By this the whole structure became apparent, and consisted of thin coats or tubes of a beautiful transparent membrane, which progressively became larger, according to the order in which they receded from the centre. These membranes were so delicate, that the fibrous texture could scarcely be discerned. The acid was tinged a very pale yellow, and ammonia changed it to a deep yellow or orange, but produced no change of transparency, or any precipitate. Exposed to a red heat, this gorgonia crackled, emitted a strong smoke, and smelled like burned horn. The shape was soon destroyed, and a compact coal remained. On incineration, a little white matter was obtained, and proved to be muriat and a little carbonat of soda. The *last species* of gorgonia which Hatchett investigated is not easily to be distinguished from the *g. antipathes*; but, upon a close comparison, this now treated of is more flat in the stem, on the thin sides or edges of which a number of short spines or protuberances are placed very near each other. That it is very different from the *g. antipathes* the following will prove. On exposure to dilute acid for nearly four weeks, the structure became apparent, and consisted of strong fibres, nearly in a parallel direction from one extremity of the branch to the other, and being closely arranged side by side, formed concentric coats of a pale

brown opaque substance; but these coats were by no means so distinct as those observed in the former gorgoniæ, although, like them, the fibrous substance possessed the character of membrane. The dilute acid was pale yellow, changed by ammonia to orange; and so large a quantity of phosphat of lime was precipitated, as to make the liquor thick and viscid. The phosphat being separated by a filter, the lixivium of potash had no effect on the clear liquor. The gorgonia, digested in boiling distilled water eighteen hours, tinged it pale yellow, and oak bark precipitated a little gelatin from it. The pieces employed, boiled with lixivium of caustic potash, formed a dark coloured animal soap; phosphat of lime was separated, and gradually fell to the bottom of the matrafs. Part of a large branch exposed to a low red heat, smelled like burned horn, and being long continued, the phosphat of lime was left, so as to retain the original figure, like bone which has been burned, but the particles of the mass cohered but feebly. The residuum being dissolved, and the phosphat separated, a slight cloud of carbonat of lime was produced by potash.

It therefore appears on recapitulation, from the above experiments on the various species of gorgonia, that the hardening substance of the *g. nobilis* (which was formerly looked upon as an iris) was found to be carbonat of lime, with a small portion of phosphat; but the matter forming the membranaceous part was (like that of millepora polymorpha) in two states; that of the interior being gelatinous, and that of the external part being a membrane completely formed, so as to cover the same, as a tube. The results of the experiments on the *g. ceratophyta*, *flabellum*, *suberosa*, *pectinata*, and *setosa*, were remarkable; for, when the two parts which compose these gorgoniæ, viz. the horny stem and the cortical substance, were separately examined, it was proved,

1. That the stems of these gorgoniæ consist of a substance analogous to horn, and that by long maceration in diluted nitric acid, this horny substance becomes soft and transparent, so as to resemble a cartilaginous or tendinous body; likewise the stems afford a quantity of phosphat of lime, but scarcely any trace of carbonat.

2. That the cortical part, on the contrary, consists principally of carbonat of lime, with very little or none of the phosphat; and the carbonat of lime is deposited in and upon a soft, flexible, membranaceous substance, which seems much to approach the nature of cuticle.

Some of the gorgoniæ subsequently examined, resembling the former in construction, did not yield any phosphat of lime, but in every other respect were similar. The *G. antipathes* was found to be entirely formed of a fibrous membrane; and the *black shining polished gorgoniæ* afforded by maceration a most beautiful specimen of membranes, concentrically arranged. Lastly, the *gorgonia* Hatchett described as very much like the *G. antipathes* proved to be similar to that species, as to the membranaceous part; but so large a portion of phosphat of lime was mixed with it as almost to approach it to the nature of stag's or buck's horn; there is, therefore, great reason to consider it as a different species.

When the *antipathes ulex* had been immersed fourteen Antipathes. days in dilute nitric acid, it became transparent, and so much softened, that from a horny substance it now nearly resembled cartilage. Ammonia changed the acid to an orange colour, but produced no precipitate, neither did potash. A portion of the antipathes, digested in distilled water, afforded gelatin. Boiled with caustic potash, it formed the animal soap. *A myriophylla* afforded the same results. The specimens were small, which prevented him from making additional experiments; but those already cited,

sufficiently prove, how much the antipathes resemble the horny stems of the gorgoniæ.

Sponges.

Many species of *sponges* were examined, but as little or no essential difference was found in the results, they may be all included in the following account. The following species, with many others not described, were investigated. *Spongiæ cancellata, oculata, infundibuliformis, palmata, officinalis*. When they had been immersed in nitric acid, diluted with three measures of distilled water, for fourteen or sixteen days, the acid became pale yellow, and pure ammonia changed it to an orange colour. The sponges thus steeped became more or less transparent, (like the gorgoniæ) and were considerably softened. In this state, the part touched with ammonia became of a deep orange colour inclining to a brownish red, and when much softened by the acid, (if afterward immersed in ammonia) they formed a complete deep orange-coloured solution, and the same were observed of the horny stems of the gorgoniæ, antipathes, &c. When digested with boiling distilled water, the sponges afforded a portion of gelatin, which was precipitated by infusion of oak bark. The fine and more flexible sponges gave it in greater abundance, and more easily than the coarse or rigid ones. The gelatin was gradually and progressively imparted to the water, and in proportion as they were deprived of it, they became less flexible and more rigid, so that the remaining part, when dry, crumbled between the fingers, or when moist, was torn easily like wetted paper.

As these properties prove, that sponges only differ from the horny stems of the gorgoniæ, and from the antipathes, by being of a finer and more closely-woven texture; (this is particularly observable on comparing the coarse sponges, as *S. cancellata*, with the finely-

reticulated parts of certain gorgoniæ, especially those of *G. Flabellum*, when divested of the external membrane) so this similarity will be corroborated by the following remarks. When exposed to heat, they afforded the same products, the same smell, and a similar coal, which, by incineration, left a very small residuum, chiefly of muriat of soda, occasionally mixed with some carbonat of lime, which was also often discovered when the recent sponges were immersed in acids; but this, as well as muriat of soda, is, according to Hatchett, merely extraneous, and arises from small shells, parts of madrepores and such like bodies, which are often visibly lodged in the interstices of the sponges. Lastly, the sponges, when boiled with lixivium of caustic potash, were completely dissolved, and, like the horny stems of the gorgoniæ, formed animal soap, more especially when the part which is apparently insoluble in water, and which remains after the gelatin has been separated, was thus treated.

This series of experiments, made by Hatchett, terminated with an examination of a few species of *alcyonium*, viz. *asbestinum*, *ficus*, and *arborescens*, all of which were found to be composed of a soft, flexible, membranaceous substance, very similar to the cortical part of some of the gorgoniæ (or *g. suberosa*), and in like manner slightly hardened by carbonat, mixed with a small portion of lime, as the following facts will prove.

Alcyonium asbestinum was unchanged in figure, after remaining several hours in dilute nitric acid; there was a feeble effervescence, and the reddish purple was destroyed. The external part became pale yellow, and was a soft, opaque, pulpy substance, within which was a stem, similar in texture, but less soft, and which still appeared of a pale red colour. Ammonia produced no effect on the filtered solution; carbonat of potash precipitated a large quantity

of carbonat of lime. A piece in a low red heat soon took fire, and melted like burned horn; after which, it retained it's figure, and became white. Dissolved in dilute acid, some animal coal was deposited, and ammonia precipitated a little phosphat of lime; after which, the carbonat was procured. A quantity of gelatin was also precipitated in the usual way. On the pieces of alcyonium, from which the water had been decanted, some lixivium of potash in it's caustic state was poured, and being boiled, the whole of the membranaceous or pulpy part was dissolved, and a substance exactly similar to Chaptal's animal soap was formed; while the calcareous part subsided to the bottom of the vessel. *A. ficus*. This was unchanged in shape in the acid, and like a strong, thick membranaceous substance of a fibrous texture. A little phosphat of lime was precipitated by pure ammonia, from the acid liquor; after which, a copious precipitate of carbonat of lime was got by potash. *A. arboreum*. The calcareous part was soon dissolved in nitric acid, but the form remained, and still appeared like a pale yellow porous substance, enveloped by a skin or epidermis. Ammonia had no effect, but carbonat of lime was obtained by potash. Incinerated and dissolved phosphat of lime was obtained, with a large proportion of carbonat. As this phosphat, therefore, appeared to have been defended by the membranaceous part from the acid, a complete solution of the alcyonium was made, and then, like that of the burned, it yielded phosphat of lime, and the liquor became orange coloured as soon as the ammonia was added. A large portion of gelatin was procured, and animal soap formed; whilst the calcareous part was separated during the boiling, and fell down in the form of a fine powder. From this examination of the alcyonium, it appears, that as the sponges resemble the horny stems of gorgonizæ, so these species of alcyonium resem-

ble in external, and chemical characters, the fleshy or cortical substance, which invests some of those bodies; and that they chiefly differ from the *gorgoniæ*, by being destitute of the horny stem, which, in the latter, seems to supply the place of bone.

From the above experiments and observations, Hatchett thinks there is reason to conclude, that the varieties of bone, shell, coral, and the numerous tribe of zoophytes with which the last are connected, only differ in composition by the nature and quantity of the hardening or ossifying principle, and by the state of the substance with which it is mixed or connected. For the gluten or jelly which cements the particles of carbonate or phosphate of lime; and the membrane, cartilage, or horny substance, which serves as a basis, in and upon which the ossifying matter is secreted and deposited, seem to be only modifications of the same substance, which progressively graduates from a viscid liquor or gluten, into that gelatinous substance so often noticed, and which again, by increased inspissation, and by the various, or more or less perfect degrees of organic arrangement, forms the varieties of membrane, cartilage, and horn. The reasons which induce Hatchett to adopt this opinion originate from a series of experiments, made with a view to investigate the nature and composition of membrane, for which, see *membrane*, *gelatin*, &c.

Concluding
remarks.

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EXTERNAL PARTS.

THE exterior coverings of animals, which appear to be produced for the purpose of retaining their heat, and as a defence against the inclemency of the weather, are *hair, wool, feathers, and silk*, which last substance serves to envelop the silk worm in it's crystalline state.

The *hair* of different animals has been imperfectly analysed by several chemists. From it's horny and fixed nature, we are told by Achard, that he was unable to extract any thing from it, by boiling it in water, in open vessels; the hair he submitted to experiment was that of the horse, the goat, the dog, the calf, human hair, and the wool of the sheep. Hair and wool.

After boiling each species of hair in Papin's digester, he found, that in one hour, it was become so soft as to give way when pressed between the fingers, and to be somewhat ropy; that it had lost very little of it's weight, but had deposited in the water a gelatinous part, which gave it a yellow, or brown colour, and left by evaporation a glue; that the hair, except the human and wool, after being dried, had become brittle, and capable of being pulverized between the fingers, which, perhaps, arose from the loss of it's gelatinous part.

Hatchett observed the same, for when hair of various qualities, and taken from different animals, was long digested, or boiled with distilled water, it imparted to the water a small portion of gelatin, which was precipitated by the tanning principle, and by nitro-muriat of tin; and when the hair had been thus deprived of gelatin, and

was subsequently dried in the air, the original flexibility and elasticity of it were found to be much diminished, so that it easily gave way, and was broken. And he is induced to believe from various experiments, that the hair which loses its curl in moist weather, and which is the softest and most flexible, is that which most readily yields gelatin; on the contrary, the hair which is very strong and elastic is that which affords it with the greatest difficulty, and in the smallest proportion. These remarks have been corroborated by the assertion of a considerable hair merchant in London, who, during a long experience of upwards of forty years, has always found, that hair of the first named quality cannot be boiled an equal time with those last mentioned, without suffering material injury in strength and flexibility.

By incineration, according to Achard, very little ashes were left behind; he found that one pound of each afforded the following quantity, viz :

| | drachms. | grs. |
|-----------------|------------------|---------------|
| Human | 1, | 20 |
| goat's | $1\frac{1}{2}$, | $\frac{2}{3}$ |
| pig's | $1\frac{1}{2}$, | 22 |
| sheep's . . . | $1\frac{1}{2}$, | 2 |
| calf's | $2\frac{1}{2}$, | 10 |
| dog's | $2\frac{1}{2}$, | 22 |
| horse's | 3, | 12 |

The colour of the ashes, in these experiments, was in general more or less yellow; whilst those from the hair of the horse were reddish. Those from the human, horse's hair, and dog's, were tasteless; and from the goat's and pig's, only as he thinks accidentally saline. The water in which these ashes had been lixiviated had no effect on the syrup of violets, which appears to prove, they contained no fixed alkali.

Neumann and Bafter, on the contrary, found a fixed salt in these ashes.

By distillation of these different species of hair, Achard ^{Exposed to distillation.} obtained, besides the carbonaceous residuum, empyreumatic oil, and the ammoniacal fluid, afforded by all animal substances, with a crystallized saline matter in the receiver, which was partly stellated, and partly rhomboidal. This, on the addition of potash, produced a very strongly penetrating smell of ammonia, and a peculiar sort of animal ammonia; which he thinks, might, perhaps, arise from the acid of benzoin, as in urine.

Digested with quick lime, during it's extinction, wool ^{Quick lime.} and human hair lost very little of their fixity, and nothing of their suppleness; on the contrary, that of the horse, goat, and dog, as well as the bristles of the pig, after undergoing this operation, and becoming dry, were very short and brittle.

Mild alkalis have no effect upon hair, either in the ^{Alkalis.} cold, or at a boiling heat; but by digesting them twelve hours with caustic alkali, they were converted into a jelly.

According to Chaptal, if a caustic lye of potash be saturated with wool or hair, a soap is formed, which he calls the soap of wool.

Hair, put into the vitriolic acid for twelve hours, in ^{Vitriolic acid,} which time it was coloured brown, had not lost any of it's flexibility, but was softer; and the human hair, after it was washed and dried, appeared partly white. On digestion in this acid with heat, the hair was perfectly dissolved, and produced a strong smell of sulphureous spirit. The solutions were not affected by dilution with water.

According to Berthollet, scoured wool put into sulphuric acid was dissolved by a slight heat; at first the solution was colourless, but on increasing the heat, it soon became blackish. Distilled with sulphuric acid, under a pneumatic apparatus, there came over a large quantity of gas, five sixths of which were carbonic acid. This acid having been absorbed, the residuum was hydrogen gas. At the end of the distillation, a considerable quantity of very white sulphat of ammonia was sublimed; there remained a coal in the retort.

Nitrous
acid.

According to Achard, fuming nitrous acid, the fumes of which immediately changed dark and black hair to a reddish, and afterward to a white colour, without affecting its solidity, corroded, and soon dissolved both hair, wool, and bristles. From this solution, pure water precipitated a yellowish flocky matter, half of which was soluble in alcohol, to which it gave its yellow colour; and on the addition of water, became milky and turbid; which, however, became clear again after the deposit of a flocky matter, greatly resembling coagulated oil. This precipitate, on being distilled, afforded an alkaline water, a large quantity of empyrenmatic oil, and a coal which left brick coloured ashes. From the nitrous solution of the human hair, when evaporated to one half, arose some small needle-like crystals. Weak nitrous acid had no effect on hair in the cold, but entirely dissolved it at a boiling heat, became yellow, and had a sweetish smell, the same as when boiled with fat oils, and other animal matters. Water, it appears, had no effect on this solution, which is somewhat extraordinary, since Berthollet having treated hair and wool with eight times the quantity of common nitrous acid in close vessels, obtained solutions, which, on becoming cool, deposited a fat matter; and on crystallization, a large quantity of

oxalic acid. This experiment of Berthollet lets great light on those of Achard. From six drachms of wool, he obtained three drachms and four grains of the oxalic acid; hair also gave it a deal of fat, but not so much oxalic acid as wool.

Achard found also, that the muriatic acid softened hair ^{Muriatic acid.} in the cold, and entirely dissolved it at a boiling heat. The dark brown, or nearly black solutions it forms, afford no deposit on the addition of water.

Berthollet found, that the muriatic acid dissolved wool more readily than the sulphuric, but a more continued heat was necessary before the solution became black. Simply distilled with a receiver to the retort, a considerable portion of muriatic ammonia came over toward the end, one part of which was brown, whilst that more advanced into the neck of the retort was white. There remained a much more considerable quantity of charcoal than with sulphuric acid; the lixiviated coal gave a solution, which contained an evident quantity of iron. To judge of the vapours by the odour, which escaped toward the end of the operation, hydrogen gas was disengaged. It may be remarked, that with the sulphuric acid, very little coal remains, but much carbonic acid is obtained; whilst with the muriatic acid, as a much greater quantity of carbon is left, we may conclude, that very little carbonic acid ought to be disengaged.

According to the experiments of Van Mons, it appears, that the oxygenated muriatic acid gas converted ^{Oxygenated muriatic acid.} quills, wool, calf's hair, and silk, after having been kept some days in it's atmosphere, into gelatin; the two first substances acquired a red colour.

Alcohol, vitriolic ether, the fat and ethereal oils have ^{Alcohol.} action upon hair either in the cold or with heat.

According to Thompson, hair, as well as wool and ^{Light.}

filk, when exposed under water to the rays of the sun, emit dephlogisticated air.

Fermentation.

From the dry and horny nature of these substances, they are prevented from undergoing the putrid fermentation; but we have an account given us by Carette, of the spontaneous combustion of wool. According to this author, wool and animal stuffs are liable to this change, when they are laid in heaps, accompanied with a certain degree of humidity. He gives an instance of an old woollen ball, which having been oiled in order to render it more elastic, and covered, some time after nothing but a black powder was found in the cover, which perfectly resembled a carbon: he also relates, that a manufacturer of Lisle, having put a piece of cloth into his warehouse which had not been cleansed, it took fire in a few days after, and that several instances of the kind had occurred.

Spontaneous combustion.

This has been observed by Sonnini: he says, in the shipping of wool it is of importance to know, that great care should be taken to prevent it's imbibing any moisture, for in such case, it heats, inflames, and is in danger of setting fire to the vessel.

Component parts.

From these experiments it appears, that hair in a chemical view resembles the fibrous parts, whilst water only extracts a little of the gelatin. Wool inclines to a fatty nature, as the lye of caustic alkalis perfectly dissolves it on boiling, and forms a soap with it as well as with hair.

It now remains to give a short description of the uses of these substances in the arts, as far as they can be considered chemically.

The arts.

It is well known that the art of the hatter consists in forming with hair, wool, and fur of different animals, a kind of stuff of a dense, compact texture, capable of assuming and preserving any figure that may be given it,

To obtain this object, a variety of processes are employed, partly chemical, and partly mechanical, which may be reduced to four principal operations, viz. felting, fulling, dyeing, and preparation.

FELTING.

IF any species of hair or wool be inspected by the microscope, it appears smooth and polished, yet if rubbed between the fingers, held by the point, and drawn to the root, the resistance is more considerable than in the contrary direction; the motion is likewise tremulous, and there is a chirping noise. Likewise, if a hair be held between the finger and thumb, and rubbed by alternately moving them in the direction of it's length, a progressive motion will be produced, which is always with the root end foremost. The same structure may be shown by tying two hairs together, and then giving the knot a few blows between the palms of the hands, for the knot will either untie itself or draw closer, according as the asperities of the surfaces are placed in tying. From this mechanism which is common to wool, and every other kind of hair, which, according to Monge, have their surface composed either of scales like those of fish or imbricated cones, like the horns of animals, may be deduced the harsh feel of woollens against the skin, compared with linens, and their irritating effect upon wounds. It is this disposition to progressive motion end ways, which causes hair to entangle and *felt* itself when pressed by the hatter between two pieces of linen, to which they do not unite from it's fibres being smooth. Cut hair is better than such as is plucked, because the bulbous roots prevent the progressive motion. The fibres of wool being

crooked, must naturally move in curves; but those of the hare, rabbit, and beaver, being straight, cannot be used alone in felting, until after a previous operation, which consists in rubbing them with a nitrous solution of mercury, by means of a brush, before they are separated from the skin. The solution acting only on one side of the hairs, renders them crooked. The straight hairs are used for felting hats, in which operation the action must be continued for a determinate time only, otherwise they would pass through and come out on the opposite side. The disposition of wool to felt itself, is an impediment to the carding and spinning processes; hence oil is used, which diminishes the power of the hairs to act on each other; but at the fulling mill, soap and marle are used, which carry off the oil and restore the wool to it's former state, in consequence of which, the fulling process takes place, and the cloths are rendered narrower, shorter, closer, stronger, and thicker. The balls of hair in the stomach of certain animals which lick each other, are felted by the action of the stomach. To which may be added, that a similar cause is the chief reason why beds of cock and hen feathers are inferior to those of goose feathers; the latter being much straighter, do not form the hard flat balls which abound in the former. This work, which is entirely mechanical, forms the *felt*, which is a kind of soft spongy stuff, of greater or less thickness, and in it's first state, of a loose and imperfect texture. It's fibres would soon disunite from their weak connection; hence to give it requisite density and consistence, it undergoes the operation of *fulling*.

Fulling.

This, which is in a certain respect the completion of felting, has for it's object the intimate connection of the fibres, and a mere perfect and durable cohesion of the whole mass. For this purpose, the mere mechanical act of pressure is insufficient; the result would be a formless

mafs without confiftence. For the fulling, it is neceffary to make ufe of a bath of water heated nearly to ebullition, into which are put, in France, ten or fifteen pounds of lees of wine, for every hundred pounds of water. The heat is kept up the whole time of working, and every three or four hours, a new quantity of lees is added. Into this bath the workmen plunge their *felt*, and begin their fecond procefs. The felt is dipped in, and immediately taken out again and fqueezed, bent and rolled, by preffure, in different direCTIONS, fometimes with the hand defended by leather, and fometimes by a roller, or other fimilar inftrument. This is repeated until the ftuff is well condensed, and has acquired the requifite folidity; hence the lees added muft be confidered as a chemical folvent, acting direCtly on the fubftance of the hair, and producing, either by foftening or swelling it, an alteration neceffary to infure the cohesion of the different fibres of the ftuff.

The editor of the French Encyclop. Méthod. affirms; that it is the alkali or potafh of the lees, which determines the fulling. Chauffier has, however, found the affertion of the editor to be erroneous; to prove which, nothing more is neceffary than to dip a piece of blue paper in the bath, which instantly becomes red, and if after feveral hours work the ftate of the bath be examined again, it is found that the acting part, which is the acidulous tartrite of potafh, is partly exhausted, and the workmen foon perceive the want of a new portion; and if we confider the fparing folubility of the acidulous tartrite in cold water, it will appear why the water muft be kept nearly boiling. Hence it is evident, that it muft act by the portion of acidule it contains. It was this firft obfervation that induced Chauffier to fubftitute the fulphuric acid inftead of the lees, which although unknown to this chemift, had been ufed as a great feeret in foreign ma-

nufactures. He found twelve drachms of this acid sufficient for one hundred pounds of water, and that this method was much preferable to that of wine lees, as being not only more convenient and economical, but the health of the workmen was not impaired by the excess and duration of the heat, the thick vapours, and the disgusting odour which exhales from the bath, particularly when the lees had been putrid and mouldy. A boiling heat is not necessary as formerly; ninety, or one hundred degrees of Fahrenheit being sufficient for good *fulling*. It also saves fuel; cauldrons of lead may be substituted for those of copper, and the felt prepared is of superior quality.

With respect to this process, it is only necessary to mention, that hats felted in the new manner take the dye better than in the old way, and that oak bark is substituted to nut-gall with advantage.

Preparation. This process, called *preparation*, consists in lining the inner surface of the crown, as well as of the brim of the hat, with a glutinous substance, which, by drying, gives firmness to the work and preserves its form. This chemist found a solution of glue in a decoction loaded with the mucilage of linseed oil the best, whilst Margueron recommends the mucilage extracted from the leaves of the horse chestnut when its foliage is in full vigour. A strong decoction of these leaves, which contains a great portion of mucous and adhesive matter, is used with the glue. These are better than gum arabic and other friable gums which become brittle.

Neumann's Chemical Works by Lewis, 2d. edit. vol. 2.—Withof, *Anatom. Pili hum.* Gotting. tom. 2.—Achar'd's *Chem. Untersuchung ueber die Bestandtheile der Haare von verschied. Thier.* in his *Chem. and Phys. Abhandlungen*. 1. p. 166.—Berthollet, *sur la Nature des*

Substances animales, Mém. de l'Acad. Royal des Sciences. 1784. Paris.—Leonhardi's Macquer's Woerterbuch, vol. 7. article *Haare*.—Monge Annal. de Chim. vol. 6.—Chauffier Observation sur le Mécánisme du Feutrage, Journ. Polytec. cap. 1, p. 160.

FEATHERS.

Feathers. THESE, according to Hildebrandt, as well as other chemists, are similar to hair. Hatchett found, that feathers, when digested in boiling distilled water during ten or twelve days, did not afford any trace of gelatin by the test of the tanning principle, but nitro-muriat of tin produced a faint white cloud. The same was observed when quill was thus examined.

SILK.

Silk. THIS is the production of the larva or caterpillar of a phalena, of which several species afford it; the phalena atlas of Linnæus gives the greatest quantity, but that from the phalena bombyx of Linnæus is the most generally made use of in Europe. The matter from which it is spun is found enclosed in two purses or small intestines of the animal, and this being taken out and extended, forms the Indian weed so well known to fishermen.

The native place of this insect is China; whence it was carried to Hindostan and Persia. Silk was not known in Greece or Rome till the reign of Augustus, and we are informed, that during several ages it was sold for it's weight in gold. In 555, silkworms were transported from India to Constantinople, by two monks, and manufactures were made at Athens, Corinth, and Thebes, whence it was brought into Europe, in 1130, by Roger, king of Sicily, on his return from the Crusade to the Holy Land; he established manufactures

at Palermo, and in Calabria; afterward it spread over Italy and Spain, and in the reign of James the First was conveyed to England.

According to Reaumur, this is not the only animal that affords this sort of matter; he found several species of spiders which enclosed their eggs in a very fine silk, and afforded a much finer and stronger thread than that of the common species; it was also of various colours, such as white, yellow, sky blue, gray, and coffee-coloured, but this has as yet undergone no chemical investigation.

Silk is of different shades of colour; from a white, it goes through all the shades of yellow, even to a reddish colour. It is of a stiff texture, and shines from the gum varnish that covers it.

It is not acted upon by water at a boiling heat (it's gum is only affected); from what, however, Chappe has said upon the subject, silk, before it is spun, and just taken from the caterpillar, may be so diluted with water as to form a sort of gluten, which may be blown into bubbles offering all the colours of the rainbow, and far superior to those balloons made of soap and water, which soon vanish. On the contrary, we are informed that those made of this silky matter are of a permanent texture, perfectly transparent, preventing even the most light gas from penetrating through it. He has formed small balloons of it, the diameter of which did not exceed three inches, which he filled with hydrogen gas, and kept suspended in an apartment, nor had many of them suffered any thing after twenty-four hours. To form this gluten, great care is required; it cannot have all it's suppleness and ductility until it has arrived at it's greatest maturity, which is when the worm is disposed to form it's silk.

Exposed to
the action
of water.
Experiments
of Chappe.

That the yellowness of which is too marked, a diseased state very common to these insects, will not do. After

being cut from the worm, it must be put into a glass, unbruised, and when a sufficient quantity is procured, it must be well washed and cleaned with great precaution; the water decanted and fresh applied. By the effect of the solution of the colouring parts of the silk, as well as of the excrementitious parts of the insect, this chemist informs us, this pure and transparent water becomes turbid, yellowish, and obscure, and in an hour, of a green, tending to a black. In this state it must be decanted and fresh water added, and repeated until the yellow is extremely weakened, and the obscure green dissipated. The thermometer of Reaum. being at 12 or 15° above zero, two hours and a half are sufficient to dissolve the colouring parts and excrements, of which it must be purged to possess all its ductility. The matter thus prepared is to be put into a glass mortar, a little distilled water added, and the mixture to be accelerated by trituration; a little more water is then added as the liquor thickens, whilst one part of water to three of the silky matter, commonly gives it all the suppleness and ductility necessary. In about half an hour after, its weak yellow colour becomes of a greenish tinge, which is the time of its being ready.

Chappe took tubes of glass, of a line or more at the orifice, and somewhat excavated at the inferior part, which he used in the same manner as in making balloons of soap and water; it must be so blown as to be made at several times, for a rapid and sudden distention always destroys it. When it has acquired its utmost extension, which, in general, does not exceed three inches, the water is let evaporate without detaching the bubble from the tube; it is then dried in the sun. To take away the internal drops of water, Chappe used a small capillary conical glass tube, by which he attracted them. The colours arise in proportion as the water evaporates, and present

themselves in the same order as those of the rainbow. Exposed to the air, it becomes tarnished and opaque, but by means of a glass and vapour, may be preserved for several years. It has been used in medallions, and as ornaments for buttons.

Berthollet found, that the nitrous acid perfectly dissolved silk. By means of seven or eight parts of the first, ^{Nitrous acid.} to one of the other, he obtained some oxalic acid, but not so much as from wool; and a fatty matter was deposited.

Welter, having treated some silk with the nitric acid ^{Nitrous acid.} in order to extract some oxalic acid, he was surprised at the end of the operation not to find any, but instead of it, he found an unknown salt, silky, of a gold colour, and which, on the approach of a red hot coal, took fire like gunpowder.

The manner in which he made the experiment was this. On one part of silk, he poured six parts of common impure nitric acid, to which he added a little concentrated nitric acid. The mixture was left to repose two days, and then distilled. He then returned what had come over into the retort again, and put it on a filter. As he thought the oxalic acid crystallized too quickly, he poured it back into the retort again, and added to it some water which had served to wash the filter. He then extracted a part of the water, and endeavoured to crystallize the residuum, which did not take place; he then added what was in the receiver to that in the retort, and distilled it again. At last, having performed the same circle of operations for several times, the residuum was an acid liquor, containing some small granular crystals, (which were not examined) and it was reduced to about one half of the silk employed.

This liquor submitted to different proofs showed no trace of oxalic acid; it was yellow, tinged the fingers of that co-

lour, and communicated to white silk a beautiful yellow, which was not weakened by washing it with water. To saturate this liquor he mixed some chalk with it, and finished the saturation by lime; having afterward extracted it, he poured some alcohol upon it, and there separated a gummy matter to all appearance, which was set apart. The alcohol was diluted with water and evaporated. There remained a yellow substance with the solutions of muriat and nitrat of lime. Having decomposed these salts by the carbonat of potash, and separated the carbonat of lime, the decanted liquor was left on a sand bath. The day after, the glass was found lined with gold coloured crystals equal to silk in fineness, which detonated like gunpowder; the smoke resembled that from burnt resin.

It's properties.

This yellow salt is soluble in water and alcohol. It crystallized on cooling. Oxygenated muriatic acid poured upon it's solution, deprives it of it's yellow colour, and renders it milky.

The sulphuric acid disengages the odour of nitrous acid from it's crystals. The muriatic acid precipitates from it's solution some small, whitish, micaceous crystals, which in the fire are volatilized into a smoke bitter to the palate. This smoke is inflammable, and burns like essential oils.

He treated some fresh silk by the nitric acid, and, after having obtained at different times crystals of oxalic acid, he poured some weak nitric acid on the residuum, which was of the consistence of honey. After having warmed the mixture to dissolve all of it, it was left to repose two days, when he again found some crystals of oxalic acid, and some granulated, yellowish crystals, extremely bitter and without any acidity, tingeing the saliva and the tongue of a yellow colour, volatile in the fire, and indestructible by the concentrated nitric acid, which only took away their colour, and this on dilution with water reappeared.

Having saturated a little nitric acid, mixed with this substance, with potash, it was evaporated, and the residuum took fire like the silky salt before mentioned. Welter looks upon this last to be a triple salt, composed of nitre of potash combined with the yellow substance to which he has given the name *Bitter*.

The crystals of yellow *bitter*, examined by the magnifier, appeared to be octoedrical, having two opposite summits truncated, whence result square rectangular tablets, the edges of which are cut sloping towards the two surfaces.

Since animal substances become yellow by the contact of the nitric acid, Welter endeavoured to extract *bitter* from the flesh of the ox; but he found it combined with another substance, which was as unalterable as itself by the nitric acid. This combination, soluble in concentrated nitric acid, is separated from it by water, in the form of a yellow powder, which does not lose its colour in the air, and which may perhaps be of use in the art of painting.

What gave Welter reason to presume that the yellow powder was composed of *bitter* and of another new substance was, that, on treating sponge by the nitric acid, he obtained some of this last substance, without colour, soluble in concentrated nitric acid like the preceding powder, and, like it, capable of being precipitated by water; knowing, besides, how greedy *bitter* is of combination, especially with animal matters, and how solid its tinctures are:

Welter thinks that bile, perhaps, owes its colour and bitterness to this substance, which he calls *bitter*.

The vitriolic as well as the muriatic acids, when concentrated, dissolve silk. Muriatic acid.

According to Westrumb, silk and wool, when treated with the dephlogisticated muriatic acid gas, or when di- Dephlog. mur. a.

luted with water, instead of being bleached like cotton and linens, always became of a yellow colour, and lost a part of their solidity.

Alkalis.

The caustic alkalis corrode and dissolve it.

Fire.

Silk, on being exposed to heat, gives by distillation the same as other animal substances. According to Neumann, few substances afforded him so much volatile alkali; and Tournefort says, that it contains more than hartshorn; from 15 ounces of silk he obtained 2 drachms of volatile salt.

Hence it appears, that silk, like coal, resembles the fibrous matter, although it has been looked upon as concrete albumen. Fourcroy looks upon it as a kind of vegetable mucilage or gummy matter, with a peculiar animal oil, which gives it flexibility, ductility, and elasticity. It, however, differs from vegetable substances; first, by the volatile alkali it affords by distillation; secondly, by the carbonic acid gas obtained from it by the nitrous acid; and thirdly, by the peculiar oil which this acid separates, in proportion as it converts it into saccharine acid. According to Gren, it is an animal-vegetable matter, the vegetable part proceeding from the food of the worm. It is convertible into paper. Gadolin found that crude silk exposed to the sun, after being moistened, afforded a great deal of dephlogisticated air.

Light.

Varnish of
silk.

Silk is divided into two kinds, viz. *unwrought* or *crude*, and *wrought*. In its natural state it is distinguished by the first name, being covered with a varnish, which by some has been looked upon as a gum, by others as a resin, to which it owes its stiffness, brilliancy, and elasticity. Bergman, on the contrary, affirmed, that this varnish was neither gum nor resin, but of an oily nature. Deprived of this it is called *wrought silk*. It likewise contains a yellow colouring part.

This varnish is soluble in boiling water, and consti-

tutes somewhat more than one quarter of the weight of the silk.

According to Berthollet, when separated it is black, brittle, and of a shining fracture.

It is easily soluble in hot water, and Berthollet found, Hot water. that it left very little residuum on the filter; the solution, which was clear and of a greenish yellow colour, was not sensibly affected, either by acids or by alkalis. A solution of alum produced a precipitate of a dirty white, that of sulphat of copper of a dark brown, and that of sulphat of iron of a brown colour. A solution of muriat of tin gave a white precipitate, and acetite of lead a brown one. All these precipitates were in small quantity, and more or less viscous. An infusion of galls or of sumach produces a white precipitate. Alcohol does not dissolve this sub- Alcohol. stance even by ebullition; it, however, takes up it's yellow colouring part.

On distillation, Beaume and Berthollet obtained the Distillation. same products as from animal substances. Hence this varnish is of an animal nature, which is the reason that soapsuds, which have been made use of to deprive the silk of it, easily become putrid. When it is no longer retained by the affinity it has for the silk, it is easily, as has been seen, soluble in water, but not in alcohol. Berthollet is of opinion, that, although this substance is not of a vegetable nature, the name of gum is well adapted to it.

The yellow colouring part which silk possesses besides It's colour-
ing part
soluble in
alcohol. it's gum, and which has been just observed to be soluble in alcohol, being separated by this means, the gum is brown, which arises from the heat it suffers from ebullition; for if this colouring part be taken off by the process of Beaume, which will be described, the silk remains white. This alcoholic solution of colouring matter left, on evaporation, a scaly residuum of an amber yellow colour.

Berthollet mixed a few drops of muriatic acid with nearly two ounces of alcohol, which he boiled on 20 grains of silk gum, when a solution took place; but, on cooling, it took the form of a jelly.

Bleaching. For the greater part of uses in the arts to which silk is destined, it is necessary that it should be deprived both of its gum and colouring part. This double object, according to Berthollet, is effected by means of soap; and to make the operation more or less perfect depends on the proportion of the soap, although it appears to change the lustre of the silk. Thus, for instance, to make it fit to receive ordinary colours, a solution of 20lbs. of soap to 100lbs of silk is sufficient, taking care to have a sufficient quantity of water, and the boiling to continue three or four hours. For silk that is to be died blue, the quantity of soap is augmented, and a larger quantity is employed for scarlet, cherry colours, &c., since it is necessary for these colours, that the ground of the silk should be whiter than for less delicate colours. If the silk is to be used white, it undergoes three operations with soap, and in the last it is called the *bleaching*, by which a light shade is given it under different names, as China white, silver white, azure white, thread white, &c.

For the China white a slight reddish tinge is communicated to it by an American seed (*bixa orellata*, Lin.) called anotta. For the azure, a little refined indigo is used. After this it is necessary to expose it to the vapour of sulphur, if intended for white stuffs, since the whiteness from the preceding processes is not sufficiently splendid.

The Abbe Columb found that silk, scoured by the action of water alone at a boiling heat, became much better for dyeing, and was more strong than that scoured by soap. A strong ebullition of eight hours, however, is necessary to dissolve all the varnish of the silk, but it preserves its yellow colour.

For a far superiour process we are indebted to Beaume, who arrived at depriving yellow silk of it's colouring part, without attacking it's gum, and, consequently, without depriving it of it's elasticity and brilliancy. Before the labours of this chemist, the art of bleaching silk was unknown in Europe; and he informs us, it cost him six years of great diligence and industry to create and bring it to perfection. The only author who had written on this subject was Poivre, who believed, that in China the silk was bleached by exposure to the sun, and he looked upon this luminary as the only bleacher of silk.

The Nankin silk is perfectly white, silvery, brilliant, and, not being deprived of it's gum, has all the stiffness natural to unboiled silk; and the great desideratum was to give that of Europe the same whiteness, without depriving it of the other properties. It was believed, that the Nankin silk was natural; and the late Soudaine obtained some eggs from China, from which he got silk both of a yellow colour and some as white as the Nankin. It appears, however, that almost all from that country is bleached by a process, which Beaume informs us he has discovered.

His first object was the destruction of the crysalis, Extinction of the cods. which pierces the silky cod in ten or twelve days. This had been effected by a furnace, heated to 70° . But the inconveniences were, that the heat spoils a part of the silk on the surface of each cod, hardens it, and makes it difficult to soften in warm water at the time of winding. One pound of spun silk is commonly procured from 8lbs. of the cods, whilst 18 ounces of the same, but more beautiful and brilliant, are procured from the same quantity of green cods, or those which had not been exposed to the furnace, and the winding is performed by a less heat and with more ease. Hence the use of a method of winding the silk, when green, without the inconveniences of the

fire; in which Beaume succeeded by means of alcohol, with this advantage, that this method shows the cods, in which the crysalis was previously dead, and which must be separated from the others, since the insect soon becoming putrid, furnishes a liquor, which gives the silk a deep brown colour; and these are distinguished by having brown or black spots on their surface.

1st Infusion. Previous to the bleaching, the wound silk must be infused in water at about 45° for two hours, to deprive it of a little of it's gummy part. During this infusion, it softens, and the water is rendered slightly amber-coloured; the silk is then dried, and being thus prepared, 6lbs. of it are put into a well washed stone pot, to which are added 48lbs of alcohol mixed with 12 ounces of very pure muriatic acid; the pot is then covered, left until the next day, or until the liquor from it's beautiful green passes to the colour of dead leaf; the liquor is then let run out by a hole in the bottom, and alcohol is poured upon the silk at several times, and let run off, until it runs off clear.

2d Infusion. The silk now undergoes a second infusion of the same kind as the first; it is then left covered twenty-four hours, or sometimes two, three, and even six days, until the silk becomes perfectly white, and is afterwards washed by pouring alcohol upon it until it runs off clear.

3d Infusion. It is now submitted to a third infusion of alcohol alone, 48lbs. of which are poured upon it; it is let stand until the next day, and the alcohol is then laid aside to wash the silk of the first infusion. When nothing more runs from it, it still retains it's weight of alcohol, which is to be washed away by clear river water, until nothing but water runs off. The marine acid likewise, with which it is impregnated, is to be washed off by the same means; but the water must contain no nitre, as this tarnishes it. The silk is placed under the pump, and coarse cloth put

over it for a filter, the water is then made to pass through the silk, until it no longer reddens the tincture of litmus ; the pot is then stopped and filled with water, which is changed once or twice every twenty-four hours, after which the silk is completely bleached and washed. If the muriatic acid be not completely washed off, the silk is rough to the touch, and in time it's threads become brittle. If it be wrapped in woollen, and placed in the current of a river, it is completely washed in five or six hours.

It appears that, although the mineral acids are of all Remarks. saline substances the most active and destructive, they may, however, be applied to silk by the intermedium of alcohol without detriment. Beaume has even used two ounces of muriatic acid to 1lb. of alcohol without any hurt to the silk, and this acid is preferable to the two others, provided it be free from the nitrous acid, as this last has the inconvenience of reddening the silk ; but alcohol mixed with muriatic acid extracts from yellow silk a colour, which immediately passes to a beautiful green tending to a blue. This on three or four hours exposure to the sun becomes of the colour of dead leaf, whilst pure alcohol alone extracts a beautiful lemon colour from the yellow silk, which is not affected by the sun, and is not deposited for several years, although the same silk, enclosed in a bottle and exposed, loses it's colour in a short time.

Alcohol alone possessing the property of taking away the yellow colour of the silk, it was the intention of Beaume to have employed it ; but, although it has the advantage of converting these yellow silks into a state of natural whiteness, and they are afterwards made perfectly white by one infusion only of the alcohol and the acid, yet it is not sufficient to bleach them entirely,

and it has likewise inconveniences which the other has not.

To this may be added, that, in order for the first infusion to have been well made, the silk must have lost all it's yellow colour, and the liquor have changed it's colour a little; that it's duration depends on it's temperature; at 20°, it is often made in ten or twelve hours; if exposed to the *baln. maræ* in two or three hours, and all the infusions may be made in one day. After this first infusion, the silk appears of a greenish colour, which goes off on washing.

By these means the yellow silks of Europe may be obtained as beautiful, and even more so, than those of Nankin, and by bleaching the white silk, which is natural, it is infinitely more beautiful.

ATTRACTION OF THE EXTERNAL PARTS FOR COLOURING MATTER.

Attraction
of the ex-
ternal parts
for colour-
ing matter.

SINCE the exterior parts of animals are converted into artificial clothing, and are subject to have their natural colours changed for a variety of others by the art of dyeing, it will be necessary, before the conclusion of this article, to take some notice of the chemical attraction they have for colouring matter.

It appears that, from the different composition of animal substances when compared with vegetable, the azote and hydrogen of the first being disposed to take an elastic state, their component particles have less adherence to each other than those of the second; hence hair, wool, and silk have a stronger attraction for colouring matters than cotton, linen, or hemp. With respect to wool, the *laminæ* or zones, which form the roughness of it's fibres,

are well fitted to contain the particles of colouring matters; but their interstices being small, no colour, according to Bancroft, can be conveyed into the cavities, until dilated by hot or boiling water, which is not the case with silk. This dilation and contraction of the interstices, with the superiour chemical attraction, which animal fibres have for colouring matters, explain why many colours, dyed upon wool and hair, proved so much more durable than on cotton and linen, and the finer and whiter the wool, the sooner and more penetrated it is with the matter, whilst the coarse wool receives colours with difficulty; likewise from it's strong attraction, wool is died scarlet in a bath, which has no effect on cotton. With respect to silk, from it's less disposition to receive and retain colours, or to combine with colouring matter, it bears some resemblance to vegetable substances, or rather seems to partake of a middle nature between the animal and vegetable, which may arise from it's fibres having neither a similar organization, by which it is capable, like wool, of having it's pores opened by hot water, of which it has no occasion, like the vegetable, or, more probably, as Berthollet is of opinion, from it's containing less azote and hydrogen; colours however dyed on silk are more lasting than when dyed on linens and cottons, which is the result of it's greater affinity with the colouring matter.

Another circumstance respecting these substances is, ^{Mordants in dyeing.} that from their difference of composition they are more likely to be destroyed by mordants*, by their greater affinity for them than vegetables have; hence, fixed alkalis, pure or caustic, destroy them by their combination to saturation, and by this means lose their causticity. Hence it follows, that wool, hair, and silk are not able to sustain the lyes, and the employment of alkalis can only be made

N. B. Mordants are those substances that serve as a medium of union between the colouring matter and the substance to be dyed.

with great precaution in the processes of dyeing them, which is unnecessary with respect to cotton, linen, &c. Wool, as it is naturally clothed with a fatty substance, undergoes the act of scouring previous to taking the dye. This is generally done by hot water and putrid urine, which, when the wool no longer is milky, is sufficiently cleansed. In this process the ammonia combines with the fatty substance, and forms a soap, which renders it soluble in water. For the generality of colours it is prepared by being boiled with saline substances, as alum, and tartar, called the *boiling*. Silk, from the same reason, as it has less affinity with colouring matter than wool, affords a greater resistance to the action of mordants; but although their action is weaker than on wool, it is necessary to make use of them with great precaution, since the brightness of colour, required in silk, appears to depend on the smoothness of its surface.

The mordant for silk is alum; without this, the greater part of the colours applied to it would have neither beauty nor durability; when, therefore, the silk has been soap-washed, it is put into a cold alum bath for about eight hours, and then washed; a hot bath would impair the lustre of the silk.

It therefore appears that alumine is the grand mordant for animal substances, and the affinity which it has for them has been proved by Berthollet by direct experiment. He formed this combination by mixing an alkali saturated by an animal substance, with a solution of alum. A double exchange was the consequence. The alkali united with the acid of the alum, whilst the alumine combined with the animal substance was precipitated. He likewise proved it by another experiment. Having mixed a solution of glue with a solution of alum, he precipitated the alumine by an alkali, which was found to have dragged the glue along with it, and to have united

with it. It had the appearance of a semitransparent jelly, and dried with difficulty. The reason of tartar being added to the alum, with respect to the wool, is, that as it is much more tender than silk, it moderates the too lively action of the alum upon it. All metallic oxyds, likewise, serve as mordants to animal substances, and even some animal substances themselves.

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